DRILL-BIT PARITY: SUPPLY-SIDE LINKS IN OIL AND GAS MARKETS

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Overview

Previous economic analyses focused on relationships between crude oil and natural gas markets centered primarily on demand-side considerations. We provide evidence that two important supply-side connections play important roles in understanding crude oil and natural gas market integration. First, crude oil production and natural gas production require a common capital input: rotary drilling rigs. Competition for this capital input should be expected to result in comovement in oil prices and gas prices. Second, crude oil wells produce associated gas, while natural gas wells often produce associated oil or oil substitutes. This latter supply-side connection could cause divergence in crude oil prices and natural gas prices, because a price shock for one commodity will increase associated production of the other commodity. Understanding which effect dominates at a particular time is essential to understanding oil and gas market integration. We construct a theoretical model based on the profit-maximizing decisions of a drilling-rig allocating firm to delineate the role played by these supply-side factors in oil and gas market integration. If rig competition is the more important supply-side factor then gas-rig allocations and oil prices will be negatively related, and vice versa, while if associated commodity flows are more important then gas-rig allocations and oil prices will be positively related, and vice versa. We then test the predictions of the theoretical model using three econometric methods, and find ample evidence of long-run relationships driven by these supply-side factors. However, we provide evidence indicating that drilling responses to price changes have changed over time, and drilling rig competition has come to play a more important role since the onset of increasing production from shale gas and tight oil wells, which began in the mid-2000's.

Methods

We develop a continuous time optimal control model of drilling-rig allocation, and derive optimal rig allocations towards oil and gas wells given cost and associated-commodity parameters. New wells drilled for each commodity are subject to exogenous decline rates as well as a fraction of production from the alternative commodity at each well – i.e., each gas well produces a fraction of its output as oil and vice versa. In addition, drilling for one commodity raises the cost of drilling for the opposing commodity by creating scarcity of low cost, high quality drilling rigs. The state variables are the rate of flow of each commodity from all previous drilling activity. We derive steady state predictions about cross price effects on drilling decisions and on prices. These predictions are tested using three stage least squares on regional aggregates of individual wells from major producing basins in the United States including the Anadarko Basin, Chautauqua Platform, East Texas Basin, Fort Worth Basin, and Permian Basin.

Results

We find significant heterogeneity across producing basins in cross-price effects on drilling activity in a pattern that's consistent with the relative importance of associated oil or gas production versus rig competition. In most basins and in aggregate, gas drilling increases in response to oil price shocks because associated oil is easier to capture and bring to market than associated gas. However, oil drilling declines in response to gas price shocks as competition for rigs is costly and the gas produced from oil wells is often difficult to capture and bring to market. These results change in basins in which more gas gathering infrastructure is available.

Conclusions

Despite a recent literature suggesting oil and gas prices, and thus markets, have become decoupled, we find significant cross-price drilling effects that are consistent with tradeoffs between scarce drilling capital and associated commodity production. Such cross-price drilling responses initate production that feeds back into equilibrium prices. The nature of oil and gas market integration has therefore changed and must take into account coproduction and input competition.