



Investment and operating choice: Oil and natural gas futures prices and drilling activity



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ABSTRACT

We present evidence that changes in oil and natural gas field investment measured by drilling rig use respond positively to changes in the futures prices of oil and natural gas, consistent with predictions based upon value-maximizing behavior. These results hold for world regions dominated by private independent oil companies but not national oil companies. In those cases where futures price changes are identified as drivers, the role of spot prices is either absent or weak. The results are robust to several alternative specifications including controls for changes in rig productivity.

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1. Introduction

A basic principle of economic choice is that expectations and beliefs play an important role in driving decisions when future outcomes are risky. This is particularly the case in the theory of real investment and operating activity, and it has both theoretical and practical relevance for the drilling choices of oil and natural gas exploration and production companies. In this study, we investigate the relation between market beliefs about future output prices reflected in futures prices for oil and natural gas and the choice to drill by oil and natural gas exploration and production companies. We study monthly drilling activity in the United States, Canada, the United Kingdom, the Middle East, and Latin America, as well as the OPEC nations taken together. To the best of our knowledge, ours is the first study of the investment/operating decision to focus on forward-looking market prices that are independent of the value of the underlying company in conjunction with activity measured at a monthly frequency.

Changes in futures prices shift the value of drilling and the optimal level of activity. The basic rational choice hypothesis is that shifts in the marginal value of drilling will be accompanied by like-signed shifts in

drilling activity. A companion hypothesis, however, is that no such underlying decision process is at work, but rather such choices are driven by other factors unrelated to value maximization. We find evidence that changes in oil and natural gas field production (proxied by changes in the use of rotary drilling rigs) are positively related to changes in the futures prices of oil and natural gas, accounting for the shape of the forward curve. We also find that a lag exists between changes in futures prices and changes in drilling activity. This result is consistent with several hypotheses that have appeared in the literature regarding factors that could delay implementation, such as adjustment costs or the presence of uncertainties that influence the threshold for the decision (the option to defer the activity). These results, however, do not hold for certain regions of the world. The regions in which no statistically significant relation is found tend to be those in which the dominant players are national oil companies (NOCs), meaning those controlled by a state. This result is consistent with the view that NOCs are driven by multiple competing objectives that either dilute or forgo completely the value-maximization dictum. We control for changes in rig productivity and costs in the analysis, and, utilizing a variety of models, find that the relation between changes in futures prices and changes in rig count is robust.

Research about the connection between expectations and economic choices has generally focused on expectations data drawn from surveys of market participants, as in the recent study by Gennaioli et al. (2015).

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These researchers relate survey evidence regarding expectations by chief financial officers about future growth to investment spending by their companies, finding that the expectations data they analyze help explain investment spending. We contribute to this discussion and to the literature on drilling choice activity by following an alternative approach to capturing beliefs about future operating performance. We make use of the fact that futures prices for a commodity can be viewed as certainty equivalent prices and that the current term structure of such prices reflects current market beliefs.¹ The primary question we ask is whether movements in oil and natural gas futures prices and their forward curves influence drilling activity choices for these commodities. In this way, we use market-determined reflections of future real market conditions to approach the question of whether beliefs and expectations have an influence on these decisions. Our work thus complements and extends the literature focusing on the relation between survey expectations and investment as well as the literature exploring the relation between spot prices and drilling activity, which we comment on later. In addition, our study focuses not only on choices in the domestic United States, but also on international activity.

In the realm of oil and natural gas production, rational value-maximizing investment choice about drilling should be a function of the futures prices for that commodity when available. This hypothesis stems directly from the observation that futures prices can be viewed as market-determined certainty equivalent prices. One advantage of casting the analysis in this way is that the fundamental value of future cash flows through the proxy of market-determined futures prices is brought to bear, and these prices are determined independently of the market value of the organization analyzing the choice. This approach, of course, represents an alternative but complement to the use of survey expectations, because it makes the implicit assumption that futures prices enter the information set used by managers when making decisions. The setting we examine is a natural laboratory for such an investigation because it involves production of a commodity for which active futures markets exist.

The activity we focus on in this study is observable at a monthly frequency, which makes it possible for us not only to use market-based forward-looking certainty equivalent proxies for cash flow, proxied by futures prices for a commodity, but also to conduct our investigation using activity data observed at a monthly frequency.

Our study contributes to the literature on investment and operating activity as reflected in drilling activity through an investigation of the relation between investment activity and futures prices. The existing literature focuses on the relation between rig use and spot prices, as in Fisher (1964), Erickson and Spann (1971), Pindyck (1978), Pesaran (1990), Favero and Pesaran (1994), Alhajji and Huettner (2000), and Ringlund et al. (2008). Our approach differs in that we account for the fact that any drilling choice today results in output in the future and focuses on future output prices that could be locked in via futures contracts. We thereby bring a new dimension to this literature.

Our investigation also contributes to the literature on the activities of companies controlled and operated by governments in contrast to privately owned companies, as surveyed, for instance, in Megginson and Netter (2001) and many others. Our study reaches across a variety of international producing regions, including both regions in which the predominant decision-making bodies are private companies (independent oil companies in our setting) and regions dominated by NOCs, whose operations are explicitly or indirectly government-controlled. Our results therefore provide

insights into the decision making of these distinctly different types of organizations as it pertains to oil and gas drilling.

Our study also contributes to the literature focused on the relation between proxies that reflect forecasts of cash flows (based on either historic cash flow behavior for a firm, as in Gilchrist and Himmelberg (1995), or analyst forecasts, as in Cummins et al. (2006)) and investment and operating activity choice. In contrast to these studies, our study relies directly on futures prices, which are market-observable certainty equivalents of future output prices. By the nature of these markets, futures prices for oil and natural gas are not determined by the values of the companies making the decisions.

The next section of the paper reviews the basic prescription for value-maximizing investment choice and the extant hypotheses that give rise to a lagged relation between investment and shifts in fundamental drivers of value change. We close the section with the presentation of an alternative hypothesis that yields no relation between investment change and value drivers. Section 3 presents a discussion of the existing literature on drilling rig use. Section 4 describes the data and empirical methods used in the study. Sections 5 through 9 present an examination of the data and the results, followed by our conclusions in Section 10.

2. Investment choice

2.1. Value maximizing choice

The choice to engage in a physical investment opportunity involving a sunk cost and an operating strategy that is fixed for the life of the opportunity can be assessed by applying the well-known net present value rule. This decision rule specifies that one should invest if the net present value based upon expected net cash flows of the venture is greater than or equal to zero, and divest if the net present value of continuing is less than zero, where the discount rate is appropriately risk-adjusted. In the context of drilling for oil or natural gas, this choice will manifest itself as an increase or decrease in the number of drilling rigs in use. Net present value, as is well known, equals the discounted incremental expected cash flows of the choice, where the discount rate reflects the risk of the cash flows (Brennan, 2003).

An alternative but equivalent approach is to compute the net present value of the choice using the certainty equivalent cash flows of the investment discounted at the appropriate risk-free rate of interest (Brennan, 2003). In most settings, the certainty equivalent approach is difficult to implement. However, when the operating choice involves a commodity that is actively traded in both a spot market and a futures market, the computation is potentially executable.

Elaborating further, assume that a series of futures contracts is available each for one unit of a commodity deliverable at each of dates t , $0 < t \leq T$, where F_t is the futures price to be paid for one unit of the physical good delivered at time t . At time 0, the uncertain price to be received at time t is the amount \tilde{S}_t . Of course, at time 0, market participants hold beliefs about the distribution of the future price conditional on the information set available at time 0. In equilibrium, the futures price F_t is the certainty equivalent of the risky price \tilde{S}_t . The value today of the uncertain payoffs to be received over the life of the investment can therefore be determined by discounting the certainty equivalent cash flows at the appropriate risk-free rates of interest. This, of course, applies to the case in which the choice cannot be deferred and the opportunity cannot be revised once begun.

The investment cost associated with the decision to drill is a sunk cost, as it is not recoverable after drilling begins. The sunk nature of this cost is a consequence of the engineering technology of drilling.

2.2. Lagged adjustment

Two prominent hypotheses have been offered for why firms generally do not immediately adjust capital or operating activities when value

¹ As a futures price observed today may or may not equal the expected future spot price at the time of delivery, we do not make such a claim; however, that futures prices can be viewed as certainty equivalent prices is not in dispute.

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