International Journal of Industrial Organization 33 (2014) 72–82

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

Asymmetric information in oil and gas lease auctions with a national company

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ARTICLE INFO

Article history:
Received 23 November 2011
Received in revised form 12 September 2013
Accepted 14 February 2014
Available online 28 February 2014

JEL classification:
D44
L71

Keywords:
Oil and gas lease auctions
Asymmetric information
National oil company

ABSTRACT

This paper analyzes bidding behavior in oil and gas tract auctions in Brazil, where the main winner has been Petrobras, a national company. We test predictions from the theory of common-value, first-price, sealed-bid auctions with asymmetric information. The tests indicate that Petrobras was better informed about tract values than other bidders. We show that Petrobras bid higher than its competitors for more profitable tracts, and that it bid more frequently than its competitors for tracts being re-offered after receiving no bids in previous auctions. We also find evidence that Petrobras could bid competitively in a limited number of auctions only, and we discuss how our results can help to improve oil and gas tract auction rules.

Published by Elsevier B.V.

1. Introduction

Information asymmetries determine how bidders behave in common value auctions. Data from various auctions, including timber rights, government securities, and oil and gas tracts, have confirmed that bidders behave similarly to what auction theory with asymmetric information predicts. However, the rules of the auction and other characteristics of the setting determine how bidders behave in equilibrium, and thus the predictions for one auction setting do not necessarily apply to others (Porter, 1995). To evaluate whether these predictions hold more generally, they must be tested in different settings.

In this paper, we test one of the most important models of auction theory using new data from oil and gas tract auctions in Brazil. We test predictions from the noncooperative first-price, sealed bid model with asymmetric information studied by Wilson (1967), Weverbergh (1979), Engelbrecht-Wiggans et al. (1983), Hendricks and Porter (1988), and Dubra (2006). In this model, one bidder is better informed about tract values than its competitors, and we assume in our setting that this bidder is Petrobras, the Brazilian national oil company, which had been a monopolist for more than 40 years before the auctions started. Based on this assumption, the model predicts how Petrobras and its competitors should bid.

Our paper is closely related to the empirical literature on private information in oil and gas tract auctions (Hendricks and Porter, 1988; Hendricks et al., 1987; Hendricks et al., 1993; Hendricks et al., 1994; Li et al., 2000; Porter, 1995). Hendricks and Porter (1988) show that bidding behavior in the U.S. outer continental shelf (OCS) oil and gas lease sales matches predictions from the theoretical model discussed above. We adapt Hendricks and Porter's empirical strategy to our setting. Our work contributes to this literature because, despite the fact that most research on oil and gas tract auctions has been based on OCS data, this setting is an exception rather than the rule in terms of country development and firm size and ownership. The United States is the only developed country among the top 20 in proven crude oil reserves (Organization of the Petroleum Exporting Countries, 2013). The 10 largest oil companies in the world by size of reserves are state-owned, and together they hold around 80% of the world's oil and gas accumulations (Economist, 2011). By studying oil and gas tract auctions with a national company in a developing country, we show that information asymmetries pervade these auctions and that the model that we test applies to other settings. Moreover, we help to understand how oil and gas tract auctions work in developing countries, a topic on which economists have demanded more information and research (see Cramton, 2007, for example).

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http://dx.doi.org/10.1016/j.ijindorg.2014.02.006
0167-7187/Published by Elsevier B.V.

We test the predictions using data from auctions for oil and gas tracts conducted in ten annual rounds from 1999 to 2008.[1] These auctions have three characteristics that allow us to test for asymmetric information. First, they have a natural candidate for a bidder with superior information, namely Petrobras. Second, they have two measures of tract profitability that are revealed only after a tract is leased, namely an indicator of whether its lessee eventually found hydrocarbons in the tract and an indicator of whether the lessee eventually also declared to the regulator that the tract is commercially viable. Third, many tracts were offered repeatedly in those auctions.

The data support the model's predictions about bidding behavior. The model predicts that if Petrobras has private information about tract profitability, then its bids should be highly correlated with profitability measures, while its competitors should not. Indeed, the data support this prediction. For example, Petrobras reported that it found hydrocarbons in and declared commercially viable 37.17 and 14.14% of the tracts that it leased, respectively, which are higher success rates than its competitors, equal to 29.24 and 7.31%. And Petrobras bid higher for tracts where it found hydrocarbons and which it declared commercially viable, while its competitors did not.

The data also support a prediction that determines whether firms bid in an auction depending on whether the tract offered is new or it has already been offered. If Petrobras is better informed about the value of a tract than other firms, the model predicts that its competitors should adjust their expectation about this value downward after they observe that Petrobras did not bid for this tract in an auction. Thus, they should be less likely to bid for this tract if it is re-offered. The data support this prediction too: while Petrobras is more likely to bid for re-offered tracts, its competitors are more likely to bid for new tracts. Still, the data do not support all predictions that we test, and we discuss possible explanations for this.

Oil and gas lease auctions in Brazil have been intensively studied recently (Brasil and Postali, 2010; Brasil et al., 2008; Matoso, 2009; Motta and Ribeiro, 2010; Moura et al., 2012; Perez, 2010; Rodriguez et al., 2008). Among these papers, the closest to ours is that of Brasil and Postali (2010), who estimate information rents in these auctions with an independent private value framework. We differ from them by using a model based on the theory of common value auctions and by using data on tract profitability and on repeated offers of the same tract to account for asymmetric information.

Our paper also contributes to the literature that investigates whether bidders learn from each other. Hortaçsu and Sareen (2005) and Hortaçsu and Kastl (2012) show that Canadian Treasury securities dealers learn about market demand based on bids submitted by their customers through them and bid based on this private information. Athey and Levin (2001) also present evidence from timber auctions consistent with private information being revealed during oral auctions. In our paper, we present evidence that bidders learn from others based on bids for re-offered items.

The paper is organized as follows. Section 2 presents the predictions from auction theory that we test. Section 3 describes oil and gas exploration in Brazil, the auction rules, and the data. Section 4 introduces our empirical method and presents the results. Section 5 discusses the policy implications of our findings and Section 6 concludes the paper.

2. Impact of private information on bids

2.1. Assumptions

In the model, one informed firm and n other firms participate in auctions for tracts using public information on tract values. The informed firm is the only one that also has private information on tract values, and for this reason the other n firms are often called the uninformed firms.

We assume that firms' bidding behavior is independent across auctions. Specifically, we assume that (i) there are no information externalities between tracts auctioned in the same round, (ii) the bidding strategy of each firm in an auction depends only on the information about the auction and the competition in it, (iii) firms are risk neutral, and (iv) the bidding strategy of a firm in an auction does not consider the effect of its bid on its payoff from future auctions for the same tract. Also, we assume that (v) Petrobras is the informed firm.

We justify these assumptions as follows: Assumption (i) should hold because the tracts are located in an extensive area, with most tracts distributed along the coast of Brazil and across a variety of sedimentary basins. Assumption (ii) is supported by the large number of firms that participated in these auctions and by the fact that many of these firms participated in only a few of them, which lowers the odds that firms use punishment strategies against their opponents across auctions. Assumption (iii) is reasonable for multinational oil companies and even for smaller firms that aimed at less risky tracts. Moreover, financial requirements imposed on bidders allowed only well-capitalized bidders to participate in the auctions. However, a number of facts indicate that bidders were risk-averse and budget-constrained, as we discuss later. Assumption (iv) implies that each firm's optimal bid in an auction is the same as if it knew that the respective tract would never be auctioned again if it did not receive any bids in the current auction. Although bidders may actually consider the effect of their bids on future auctions for the same tract, we believe that the weight of possible future auctions is small in bidders' current payoff function.[2] Moreover, this assumption keeps the model relatively simple. Assumption (v) is justified by Petrobras's many years of exclusive experience in Brazil before the auctions started, as we discuss in Subsection 3.1.

2.2. Predictions

Hendricks and Porter (1988) test the first five predictions below, which we adapt to our setting. Based on the model that they use, we also derive a sixth prediction:[3]

P1. *The event that the informed firm bids occurs more frequently than the event that at least one uninformed firm bids.*

P2. *The informed firm wins at least one half of the tracts, conditional on the event that at least one firm bids.*

P3. *The distribution of the informed firm's bid has a mass point at the reserve price, but the distribution of the maximum uninformed bid does not.*

P4. *The bidding strategy of the informed firm is an increasing function of the public signal, when a higher signal is "good news."*

[1] In this paper, we use the word "round" to refer to the annual event where tracts were auctioned. Because we study sealed bid auctions, the reader should not confuse the meaning of "round" with a turn within an auction where participants can revise their bids, such as in English auctions.

[2] Assumption (iv) is adequate as long as bidders' risk-free discount rates are high, they believe there is a low probability that the tract will be re-offered, they believe there is a low probability that they will win it in a future auction conditional on being re-offered, they expect a low payoff conditional on winning it, and they do not hold private information about its value that could be revealed if they do not bid.

[3] The first five predictions correspond, respectively, to predictions 1 and 2 on page 870, an unnumbered prediction on page 869, prediction 7 on page 871, and an unnumbered prediction on page 877 of Hendricks and Porter (1988). The four remaining predictions on page 871, namely predictions 3, 4, 5 and 6, cannot be properly tested with our data. Predictions 3 and 4 require an estimate of expected profits which cannot be built into our setting, because the large majority of tracts in our sample have not produced any hydrocarbons yet. Prediction 5 assumes that c is equal to zero, which is unrealistic given that Petrobras was an incumbent in this market. Prediction 6 ideally should be tested using data on the actual number of potential uninformed bidders in each auction, which we do not observe. Alternatively, we could use the number of uninformed bids as a proxy for the number of potential bidders, but we do not consider this an adequate measure in our setting. For instance, the large number of auctions that received bids from Petrobras above the reservation price but no bids from other firms suggests that in many auctions the number of potential and effective uninformed bidders differed substantially.