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AN ASYMMETRIC STRUCTURAL MODEL ON DRAINAGE OIL LEASES

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Abstract

Overview

This paper studies federal auctions for oil and gas exploration rights on the Outer Continental Shelf (OCS) from 1954 to 1970. We focus on drainage leases where firms have asymmetric information about the value of the tract prior to bidding. We consider a structural common value model with two types of firms where one type has superior information about the value of the tract. We then estimate structural parameters to show that "winner's curse" exists for the less informed bidder and they behave rationally taking it into account.

Three kinds of oil and gas lease sales are handled by the Department of the Interior: wildcat sales, developmental sales, and drainage sales (Porter, 1995). In wildcat leases firms have symmetric information based only on private signals from seismic and tract specific surveys, whereas they are asymmetrically informed in drainage leases which are adjacent to tracts on which a deposit has been discovered. The source of the informational asymmetry is based on the fact that firms that already own a neighbor tract have more informative signals than non-neighbor firms can have from public surveys. This is because neighbor firms have the private information from exploratory drilling in the neighbor tract. Since tracts are expected to be spatially correlated, this drilling information is more precise than other public information. This interesting auction environment has been studied widely in the literature since the pioneering paper of Wilson (1967). His model is later extended by Engelbrecht-Wiggans et al. (1983) and Hendricks and Porter (1988). These papers consider an asymmetric common value model with one informed and one or more uninformed bidders. Private information of the informed bidder is superior to the public information of the uninformed bidder. Hence, "winner's curse" is present only for the uninformed bidder. Equilibrium of this game consists of a pure strategy for the informed bidder and a mixed strategy for the uninformed bidder. Hendricks and Porter (1988) test the bidding behavior in equilibrium using the data for drainage leases from 1954 to 1970. They conclude that the data is consistent with the theoretical predictions of the model, and bidding is likely to be collusive among informed bidders. The intuition for the last argument is that informed bidders may have formed a joint venture to the sale in order to manage production from the common pool. This would also have provided neighbor firms with a mechanism for distributing the benefits from cooperation. Neighbor firms which did not bid could have received transfer payments through the allocation of production. Furthermore, considering the fact that the government rejected 15% of the high bids, Hendricks et al. (1994) studies the same model imposing a random reserve price. They claim that it is very unlikely to find an alternative model consistent with the data.

This paper uses the same theoretical model, and estimates its structural parameters and bid functions to quantify "winner's curse" for drainage leases. Though the series of papers by Hendricks and his coauthors compares data with model predictions, structural estimation to reveal the latent relations has never been done. The paper also contributes to the literature on structural estimation of auctions which was started by Paarsch (1992). Most of the previous work in this area focused on symmetric models (Laffont et al. (1995), Guerre et al. (2000), and Bajari and Hortacsu (2003)). Although there are papers that study asymmetric models such as Jofre-Bonet and Pesendorfer (2003) and Campo et al. (2003), they consider private value settings. As far as we know, this is the first paper to structurally estimate an asymmetric common value auction model. Another interesting feature of the paper is that estimation is carried out under the assumption that informed bidders behave collusively (Athey et al. (2008), Porter and Zona (1993)).

In general, estimation of common value models suffers from identification problems and non-linear bid functions. Without further specification one would expect a more complicated situation when bidders are asymmetric. Nevertheless, estimation of our model is simplified due to two factors. First, asymmetries are not arbitrary in the model. Uninformed bidder does not have any private information that informed bidder may want to know. Thus, "winner's curse" is only an issue for the uninformed firm. Moreover, since uninformed firm only has a public signal, it would be totally predictable by the informed firm if uninformed bidder follows a pure strategy bidding rule. In this case there is no way to make positive profits for the uninformed firm. Therefore, to make itself unpredictable, the uninformed firm follows a mixed strategy in equilibrium. Under this extreme informational advantage, bidding strategies are significantly simplified for the econometric analysis. The second simplifying factor is related to the data. Identification of the model, which is problematic in common value models as noted by Laffont et al. (1996), is facilitated by an ex-post measure of tract value calculated by Hendricks and Porter. They obtain this value as discounted revenues less discounted drilling costs and royalty payments. They converted production flows into revenues using the real wellhead prices at the date of the sale, and discounted them to the auction date at a 5% per annum rate. The American Petroleum Institute conducts an annual survey of drilling costs of wildcat and production wells for different regions including offshore Louisiana and Texas. Hendricks et al (2003) also states that there are several potential sources of error in their measure of ex-post tract value. Hence in the estimation I take this value as an approximation and assume that the unknown value of the tract, V, is normally distributed with its mean and variance being linear in this approximate value.

Empirical Methodology

We will follow the same modeling assumptions in Hendricks and Porter (1988). There is one informed neighbor firm and a varying number of uninformed firms. Both types are risk neutral. As discussed above, we allow for collusive behavior among neighbor firms. So, when there is more than one bid from informed bidders, we only consider the highest of these as the representative bid of the collusion. Non-neighbor bidders observe the public information and they do not have any other private information. Note that one can ask at this point whether non-neighbor firms can have private signals from seismic surveys. This type of modeling has also been studied in the literature by Kagel and Levin (1999) and Campbell and Levin (2000). Though it seems to be a better approximation to the real auction environment and brings competition between informed and uninformed firms, it would provide a poor fit to the data as discussed by Hendricks et al. (1994). So we stay with the extreme informational asymmetry assumption. Neighbor firms observe public signal and also have their private information. We also assume that uninformed firms only consider the private signal of the informed firm when correcting for "winner's curse" in their optimization problem. As a result, conditional on the public information, bids are distributed independently. Optimal strategy for each type of firm is derived as in Hendricks and Porter (1988). For the econometric analysis, given public information, we assume that informed bidder's private estimate for the value of the tract is normally distributed conditional on the tract value, V, with its mean and variance being linear in V. Using the Jacobean transformation we get the distribution function of the neighbor bids. Moreover, the optimal bidding strategy of the non-neighbor firms is a distribution function conditional on public information, since non-neighbor firms play mixed strategy. We assume that the distribution function of the bids of uninformed firms is exponential given public information. Then we construct the likelihood function for bids given public information. We use a simulated maximum likelihood approach (Gourieroux and Monfort, 1996) since likelihood function includes integral with respect to the unknown common value, V. Having estimated the structural parameters of the model, we estimate the bid functions of both types. Finally we define a measure for "winner's curse" for the uninformed firm and estimate it.

Expected Results

Hendricks et al. (1988) showed that the predictions of the proposed theoretical model are consistent with the data. Thus, we expect to find a good fit for the model. Given the high informational asymmetry we expect to find a significant quantity for "winner's curse". Moreover, as an empirical test of the model we also expect to see a monotonic behavior for the bid function of the informed bidder on a particular subset of its support.

Summary and Conclusion

This paper proposes a structural estimation method for a widely used theoretical model to explain bidding behavior in drainage leases. The model is also a first step in the structural estimation of asymmetric common value models. Collusive behavior among neighbor firms is taken into account in estimation. Structural parameters enable us to estimate the bid function and the extent of “winner’s curse”, which cannot be estimated by reduced form regressions employed in previous research. Since the bid functions are simplified due to the nature of the bidding environment, modeling entry behavior may be a fruitful extension for future research.

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