An Empirical Analysis of Auctions for Oil and Gas Exploration Leases in India and their Implications for India's Energy Transition

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Overview

This paper presents an econometric analysis of the correlates of successful bids in oil and natural gas auctions in India between 1999-2010, covering the period from the liberalisation of the upstream sector to the present. The motivation for this paper is twofold. The first relates to India's long term (2030) policy goals towards reorienting its primary energy mix to reflect less dependency on imported oil and coal, and more emphasis on indigenous natural gas as a 'transition' fuel towards attaining low carbon objectives. India's consumption of primary energy is expected to triple from 559 mtoe in 2011, comprising mainly oil and gas, to reach between 1,514 – 2,289 mtoe by 2030 according to the IEA's New and Current Policies Scenarios, and the Indian government's own estimates, based on GDP growth rates of 8 to 9 percent. This is an amount roughly equivalent to the consumption of China or the USA today (Camilleri, 2013). As part of efforts to meet this projected increase in a sustainable manner, a focus on natural gas has emerged the preferred policy option, and involves increasing current production levels fivefold by 2030 (Government of India, 2006). It naturally follows that the attainment of these future goals is contingent on the efficiency of the upstream regime for gas exploration. The second motivation relates more immediately to a crisis in fuel supply being experienced in India, infamously demonstrated by blackouts across 20 northern states in July 2012, affecting 600 million people over a period of two days. This coincided with a persistent decline in gas production since 2010 to just 30 percent of expected targets, prompting a major review of the upstream regime for exploration.

In this context, this paper analyses and evaluates the system of first price sealed bid auctions used in allocating leases for oil and gas exploration under India's 'New Exploration Licensing Policy', launched in 1999. Nine rounds of auctions have been conducted to date under the Policy. Under each auction, bids for leases on a number of 'blocks' of acreage were invited from exploration companies, on a set of criteria relating to the bidder's technical and financial capability, fiscal bid and work programme bid, each of which was assigned a weight by the federal Indian government (acting as auctioneer). These weights reflected the relative importance of each criterion in the decision to award leases. Using these weights and the bids submitted, the auctioneer (government) computed a composite score out of 100 for each bid. The highest scorer for a bid on a block was thus awarded the exploration lease for that block.

Following the literature by Illedare et al (2004), Porter (1995), Markham (1970) and Gilley and Karels (1986) on analyses of lease auction market performance in the USA, this paper utilises an original dataset of variables covering nine rounds of auctions in India, representing the 'value' of the winning or successful bid on each block (measured by its score out of 100) as the dependent variable, and a set of explanatory variables representing bidder characteristics, bid characteristics, market structure and factors such as oil prices and prospectivity. Since such a score is a proportion-valued variable, we use fractional logit models to estimate the responsiveness of the high or winning bid to the explanatory variables, thus providing an understanding of the dynamics of the upstream sector in India. Apart from being the first such academic study of hydrocarbons auctions in India using a unique dataset, this paper contributes significantly to existing academic literature by relating the results to India's supply side crisis, and to its attempts at an energy transition away from the import of oil and coal towards the increased use of indigenous natural gas as a transition fuel.

Methods

The paper draws on auction theory in setting up the problem to be analysed and in interpreting the econometric results. Oil and gas auctions in the theory are characterised by *almost common values* amongst bidders; namely, that each bidder's value of a block will be based on mix of his private values (determined, for instance, by geological expertise), and on shared or common values amongst all the bidders (for instance, the expected quantity of production from the exploration area, valued at the international price of oil). Participants in almost *common value* auctions are known to be susceptible to the phenomenon of over-bidding, popularly known as the 'winner's curse'. These auctions are also susceptible to standard microeconomic problems such as market entry and collusion. The literature further details the characteristics of *almost common* value auctions which can be reasonably observed for in our empirical results.

Empirical Approach

This paper is based on an empirical approach from existing literature which specifies that the value of the high or winning bid is a function of three sets of factors: economics, structure and conduct. This specification has been used successfully in existing literature to analyse lease auction market performance (Illedare et al, 2004; Markham, 1970; Gilley and Karels, 1981; Porter, 1985). The general specification is:

$$HB = f(V, S, C, Z) \quad \text{where;}$$

HB represents the magnitude of the high or winning bid for a lease; V represents the set of factors which capture the expected gross value of the lease, or the 'economic' factor; S defines factors that represent the degree of competition in the leasing programme;
C is a set of factors (dummy variables) that serve as proxies for the behaviour of bidders in terms of the types of bids, and whether the bids were competitive or not; Z represents other variables postulated to be relevant to the value of the lease, such as firm size, prospectivity, as well as time-associated events such as policy changes and trends in oil prices. We use a dataset of similar variables for India spanning the years 1999-2010, representing nine rounds of auctions.

Econometric Method

The dependent variable of interest is a score between zero and hundred, so that rescaled, it is a proportion between zero and one. We estimate conditional models for proportion-values. Conditional models for proportions can roughly be categorised into models which

- parameterise the conditional density versus those that parameterise the conditional expectation,
- models that take into account the extreme values, {0, 1}, and those which do not.

Beta likelihood model:
The outcomes Y_i given the predictors can be modelled as conditionally Beta-distributed

$$f_{Y|X}\left(Y_i \middle| X_i; \phi\right) = \frac{\Gamma(\phi)}{\Gamma(\mu_i\phi)\Gamma((1-\mu_i)\phi)}\, Y_i^{\mu\phi-1}(1-Y_i)^{(1-\mu_i)\phi-1}$$

where: $$g(\mu_i) = X_i^{\intercal}\beta$$

Here $g : [0,1] \mapsto \mathbb{R}$, is the *link* function as in GLMs. We use the logistic link function (other possibilities include the probit, complementary log-log, and the log-log). Estimates of the model parameters can be computed by maximum likelihood. However, this model ignores the {0,1} values, and further, it presumes that we can correctly specify the conditional distribution of the outcome variables.

Bernoulli QMLE:
Another possibility is to specify the conditional expectation of the outcome variable as for the logit model

$$\mathbb{E}\,(Y_i|\, X_i; \beta) = \Lambda\left(X_i^{\intercal}\beta\right).$$

Where Λ is the CDF of the logistic distribution.
The Bernoulli Likelihood, which can be written as

$$L_n(\beta|\, Y, X) = n\, \sum_{i=1}^{n}((1-Y_i)\log\left(1 - G\left(X_i^{\intercal}\beta\right)\right) + Y_i \log\, G\, (X_i^{\intercal}\beta))$$

is a member of the linear exponential family (where G is an arbitrary function that maps to (0, 1)). If we assume that the conditional mean is parameterised correctly, the QMLE from maximising the Bernoulli likelihood with the conditional mean as above (setting G ≡ Λ) yields the most efficient consistent estimator among estimators that specify only the conditional mean (Wooldridge, 2011). This is the *fractional logit* model.

In both these cases, standard errors of parameters are computed using cluster-robust standard errors where clusters are defined in terms of the auction rounds.

Expected Results

Preliminary results from the econometric analysis indicate that auctions for hydrocarbons leases have not always led to what might be considered 'efficient' outcomes in the auctions literature; these outcomes may in fact have contributed to the slower than expected pace of exploration, development, and consequently lower than expected production levels, particularly in natural gas. Several variables show up as significant in the marginal effects in the fractional logit models. For instance, blocks located in unexplored deepwater areas, which intuitively stand a greater chance of yielding discoveries and should therefore be valued higher have in fact led to marginally lower values on the winning or high bid. Another significant result indicated that a block receiving multiple bids was more likely to lead to a marginally higher value on the winning bid, than a block receiving a single bid; further the value of the high bid was likely to be marginally lower if the bid was a joint bid rather than a solo bid, signifying the fact that joint bids have tended to shrink the market and the number of potential bidders. These and other results related to market structure and bidder characteristics are explored and interpreted further in the paper. The paper also offers policy options towards ensuring that auctions lead to desired long term outcomes within the context of Indian energy policy; namely, sustaining the production of natural gas over the next two decades and thus reforming the system to ensure that policy targets are achieved. These options relate to the use of reserve prices to better evaluate bids, greater clarity on the objectives of the auctions, and considering the use of different auction formats for different geological types.

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