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INTRODUCTION

This article uses multiple regression analysis to evaluate the effectiveness of the leasing policy employed by the federal government in the first sixteen years of leasing Outer Continental Shelf (OCS) lands for oil and gas development. The dominant system for leasing these lands has been the cash bonus bidding system, which allocated leases to the bidder offering the largest up-front payment, called the bonus payment. Winning bidders are also required to make nominal rental payments on lands under lease but not yet productive. These payments are then superseded by royalty payments on leases which become productive, amounting to 16²/₃ percent of production value or of the volume of production for those royalties taken by the government in kind.

The degree to which bonus payments have dominated the flow of revenue to the government under this system is illustrated by the fact that, for the 3,919 OCS oil and gas leases issued through 1980, the federal government has received $30 billion in bonus payments compared to only $10 billion in royalty payments and $260 million in rental payments.[1] As might be expected for a system involving the transfer of billions of dollars from private firms to the government for the right to exploit valuable public lands, the cash bonus bidding system has attracted critics. Some question whether the government ought to lease at all without first discovering the true value of the resources involved; others believe the present leasing system gives competitive advantages to large firms which can more easily finance the large bonus payments or lead to anticompetitive outcomes (lower payments to the federal government) because of joint bidding among firms.

These objections to the bonus bidding system have been appraised by the present authors, and our analysis does not support the critical arguments.[2] This study estimated the aggregate profitability of leases, both

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1. U.S. GEOLOGICAL SURVEY, OUTER CONTINENTAL SHELF STATISTICS, 7, 47 (1981).

2. Mead, *The Rate of Return Earned by Lessees under Cash Bonus Bidding for OCS Oil and Gas Leases*, 4 ENERGY J. 37 (1983).

in terms of after tax internal rates of return and present values, to discover how closely the estimated profitability of leases approximated the opportunity cost of OCS investments. It was concluded that the cash bonus bidding system has produced competitive rates of return for lessees in the aggregate, and for various groupings of winning bidders by size of firm and by type of bidder, either joint bidder or solo bidder.[3]

Critics of bonus bidding have been successful, however, in persuading Congress that this system may lead to anti-competitive results, or to the sale of leases at less than fair market value. Congress responded by passing the OCS Lands Act Amendments of 1978,[4] which required that a minimum of 20 percent and a maximum of 60 percent of all new leases offered for sale in the first five years following the passage of the Act must be based upon leasing systems other than cash bonus bidding.

This article evaluates the effectiveness of the bonus bidding system utilizing regression analysis, in order to provide additional perspective on the questions raised by critics of the system. More specifically, this study analyzes the effects on high bids of three sets of variables representing (1) the perceived economic quality of the lease at the time of the auction; (2) the amount and distribution of information among bidders; and (3) the structure of competition for the lease. The analysis is based on the record of the 1,223 OCS leases awarded in the Gulf of Mexico over the years 1954–1969. These leases have a sufficiently complete record of development and production to provide a valid basis for analyzing questions relating to the vigor of competition, including the effects of firm size and joint bidding on the size of bonus bids received by the government for leases issued during the period studied.[5]

The article is organized as follows: the first section discusses the theory of competitive bidding; the second section describes the methodology of multiple regression analysis which is used here; the next section defines the regression model variables and explains the economic hypotheses which are to be tested using the analysis; the fourth section presents analytical results; and conclusions are presented in the final section.

THEORY OF COMPETITIVE BIDDING

An extensive literature exists to model the decisionmaking behavior of bidders in auctions where the object of the auction is not known precisely and where bidders realize their mutual dependence.[6] The ob-

3. *Id.* at 50-51.
4. Pub. L. No. 95-372, § 205.
5. The regression analysis relies upon the Lease Production and Revenue data base maintained by the U.S. Geological Survey (USGS). For each lease, this data base includes information (through 1979) on (1) the amount of each bid and the identity of the bidders; (2) annual production of oil and gas; (3) annual royalty and rental payments; and (4) the well drilling record (by spud date).
6. Englebrecht-Wiggans, *Auctions and Bidding Models: A Survey,* 26 MGMT. SCI. 119 (1980).

jective assigned to each bidder in these theoretical models is to choose a bid so as to maximize economic returns adjusted for the level of risk exposure. The optimum bid is most often a function of the value estimate developed by the bidder prior to the auction, the degree of uncertainty associated with this estimate, and the number and bidding strategies of competitors.

The interaction of several bidders at the lease auction establishes the high bid for each lease, B_{MAX}, which is of primary interest in this article. Theoretical bidding models which assume that bidders are identical in all respects imply that the high bid is positively related to the expected value of the lease and number of bidders, and negatively related to the amount of uncertainty regarding its value. As the number of bidders grows indefinitely large, B_{MAX} tends toward the true value of the lease.[7]

Bidders in OCS lease auctions differ in size, experience in OCS lease operations, bidding form, whether joint or solo, and in the amount and quality of information they have at the time of the auction. These differences among firms can be expected to lead to differences in bidding strategies and thus have an impact on the high bid. Certain bidding models assume an uneven distribution of information among bidders. These models demonstrate that the bidder in possession of superior information should bid more aggressively than less well-informed competitors.[8]

The regression results which are reported in the section on analysis indicate that the size of winning bids for OCS leases is related not only to the number of bidders participating at each auction, but also to the amount of information available to bidders at the time of the auction, as suggested by the theoretical models referred to above.

METHODOLOGY

This study uses multiple regression anaylsis to examine a number of questions relating to the determination of the winning bid in OCS lease auctions. The starting point for the analysis is the development of theoretical hypotheses about the economic behavior of interest. These hypotheses are then expressed in the form of mathematical equations.

The issue in this article is how the level of the winning bid, the dependent variable in the models which follow, is affected by variations in a series of other variables, called independent variables, which are presumed following the theory to be functionally related to the dependent variable. The independent variables are chosen to represent important

7. These properties of the winning bid have been established theoretically by Reece, *Competitive Bidding for Offshore Petroleum Resources*, 9 BELL J. ECON. 369 (1979) and Wilson, *A Bidding Model of Perfect Competition*, 44 REV. ECON. STUD. 511 (1977).

8. *See* Dougherty and Nozaki, *Determining Optimum Bid Fraction*, 27 J. PET. TECH. 349, 352-53 (1975).

characteristics of the lease market, such as the expected value of the lease, the nature and extent of competition in the lease market, and the amount and distribution of information possessed by bidders.

Regression analysis permits one to test whether relationships suggested by theory actually exist in the real world, technically, by the presence or absence of a statistically significant relationship. Where an outcome of interest (in this paper) the size of the winning bid is simultaneously affected by several other variables, regression analysis permits the separation of the individual impact of each of the other variables, in effect validating or invalidating a postulated relationship between the dependent variable and each independent variable.

The regression models employed in this study follow this general formulation:

$$B_{MAX} = f(V, C, I, D)$$

The dependent variable in these regression models is the natural logarithm of the high bid.[9] The independent variables fall into categories which characterize certain features of the lease auction, as follows:

- V is composed of variables which capture the expected value of the lease;
- C characterizes the competitive structure of the lease market;
- I characterizes the amount and distribution of information available to bidders; and
- D is a set of proxy variables (or dummy variables) which are used to correct for the pooling in the dataset of time series data (from different lease auctions) and cross section data (from any one lease auction).

REGRESSION MODEL VARIABLES: DEFINITIONS AND HYPOTHESES

The independent variables in the regression models used in this study have been chosen to reflect the characteristics associated with the categories labeled V, C, I, and D above. These variables are defined more carefully in the sections below.

Variables Relating to the Expected Value of the Lease

1. The natural logarithm of the present value of production (LNPVP)

Firms engage in pre-sale geophysical and geological activities because exploratory information has positive value in identifying and evaluating

9. Natural logarithms are used to measure high bid and also several of the independent variables included in the analysis because the relationships involved are presumed to be non-linear.

productive tracts. Although pre-sale tract evaluations are subject to a high degree of uncertainty, it is reasonable to hypothesize that a positive correlation exists between what firms think a tract is worth, based upon presale exploratory activities, and the ultimate production from the tract. Because it may be assumed that tracts with more promising geological indications are, on average, more productive than other tracts, the record of productive value for each tract can serve as a proxy for the perceived value of the tract at the time of the lease sale. For each lease, twenty-six years of production are included in the measure of present value (LNPVP). Thus, leases issued in 1954 included the entire period of production through 1979, while leases issued in subsequent base sales encompass both historical and forecasted values or production over a total time period of twenty-six years.[10] The discount rate used to compute present value is 10 percent, a rate believed to be representative of that used by the oil industry for investment decisionmaking in the period of these lease sales.[11]

2. *The natural logarithm of the number of wells drilled within twenty-four months (LNWELL24)*

Since over 60 percent of the leases in this study were dry, the LNPVP variable representing the present value of each lease cannot alone serve as an adequate proxy for the perceived value of each lease at the time of the lease sale. Additional variables are needed to further differentiate among leases with respect to perceived quality. One of these is the log of the number of wells drilled within the first twenty-four months following the lease sale. It is reasonable to assume that firms having an inventory of leases awaiting development would drill first on those tracts which are most promising.[12] Those wells drilled within the first twenty-four months would most likely be exploratory rather than production wells. Higher levels of exploratory drilling on a lease reflect higher expectations concerning the lease's potential for production; thus, the LNWELL 24 variable would be expected to be positively related to the high bid.

10. Production value forecasts are based on a .15 exponential decline rate for production. *See* Mead, Competitive Bidding Under Asymmetric Information at A-11 (Jan. 31, 1982) (Final Report to the U.S. Geological Survey, Reston, Va.). The natural gas price forecast reflects the provisions of the Natural Gas Policy Act of 1978. *Id.* at A-11, 12. A commercial oil price forecast (by Data Resources, Inc.) was the basis of our future oil price assumptions. *Id.* at A-13, 14. The net oil price realized by most lessees probably did not deviate much from what was anticipated at the lease auctions, despite the rapid increase in the market price of oil in the 1970s, because of the imposition of federal price controls which classified production from all leases in the sample as "old oil," and because the maximum windfall profits tax rate is currently applied to production from these leases.

11. This discount rate reflects the opportunity cost of total invested capital, rather than equity capital alone for which a higher discount rate would be appropriate.

12. Profit maximization requires that lower-cost resources be developed prior to higher-cost resources in order to preserve the intertemporal equality of the discounted value of marginal benefits yielded by each lease in the inventory through the date of exhaustion.

3. The natural logarithm of the number of acres in the lease (LNACRES)

In making pre-sale evaluations, firms analyze the geology of each tract to determine the nature and extent of hydrocarbon-bearing rock. The amount of recoverable hydrocarbon increases as the horizontal area of the lease increases, for any given vertical structure of rock. Thus, an increase in tract acreage increases the size of probable reserves, other factors being the same.[13]

4. The natural logarithm of water depth (LNWATDEP)

The expected value of the lease will decrease with each increase in the anticipated costs of developing the lease. Costs of well drilling and platform construction are the most important costs associated with lease development. Cost differences in the offshore environment are strongly related to water depth, since deeper water requires more costly platforms and wells.[14] Greater water depth is also generally associated with greater distance from shore, which implies more costly transportation of workers and materials and longer pipeline distances. These facts suggest that the high bid for a lease should be negatively associated with water depth, other things being equal.

Competitive Structure of the Lease Market

1. The natural logarithm of the number of bids (LNNBIDS)

Theoretical bidding models conclude that the correct strategy for any individual bidder is that the bid should be a decreasing function of the expected number of competitors.[15] Despite this rule of strategy, these models conclude that the high bid in a competitive auction will be an increasing function of the number of bidders for the reason that the positive effect on high bid of additional bidders more than makes up for any adjustment in the level of bids by individual bidders. Thus, it is expected that an increase in the number of bids for a lease, which may be interpreted as an increase in the intensity of competition for the lease, would be positively related to the high bid.

2. Firm size of winning bidder, Big-8 or non-Big-8 (BIG801)

A variable distinguishing bidders by size is included in the models below to test two alternate hypotheses concerning the effect of firm size

13. The 1,223 leases studied here vary in size from 50 to 5760 acres.

14. Cost differences which occur because of changes in technology or other factors relating to the different lease sale years are accounted for in Model 2, below, which isolates the effects of "year of sale" on the level of high bid.

15. *See* Gilley, et al., *The Competitive Effect in Bonus Bidding: New Evidence*, 12 BELL J. ECON. 637 (1981).

on high bid.[16] The first hypothesis suggests that large firms exercise market power in OCS lease auctions and, therefore, pay less than other firms for leases of similar perceived quality. The second hypothesis, contradictory of the first, but raised also by critics of bonus bidding, suggests that large firms have financial advantages in borrowing money or spreading risk which permit them to pay higher bonuses for leases, squeezing smaller firms out of the market. The first hypothesis suggests collusion among larger firms to rig the price paid for OCS leases. This is highly unlikely since the number of firms participating in this market is large and there is no mechanism in a sealed bid auction to prevent firms which were not part of a collusive agreement from entering higher bids.[17] Support for this conclusion is given in the fact that in the entire period of OCS leasing since 1954, there has never been a case of alleged bid-rigging.

In regard to the second hypothesis, large firms could consistently outbid other firms and still earn a normal or higher rate of return on their OCS investments, assuming a competitive auction market, only if there were imperfections in capital markets favoring larger borrowers or if larger firms had special expertise in some aspect of exploration or development of leases which would result in lower costs for them or an increased probability of finding oil or gas on a lease. The fact that smaller firms may participate in OCS lease investments through the vehicle of joint ventures, together with the practice within the industry of assigning the role of lease operator to the partner in any joint bidding combine which has the greatest expertise in lease development leads to the conclusion that there is little likelihood that large firms could consistently outperform small firms in this market.[18]

The most likely hypothesis concerning the effect of firm size on high bid is that firm size should not be a statistically significant determinant of the level of high bid.

3. Character of winning bid, joint or solo (JOINT01)

The practice of joint bidding by firms for OCS leases has been cited by oil industry critics as a case of government-sanctioned practices leading to anticompetitive behavior within the industry. These critics were successful in convincing the Department of Interior to ban joint bidding

16. The variable used, BIG801, has a value of 1 if a winning bidder was a Big-8 firm or if any participant in a joint winning bid was a Big-8 firm. Firms were ranked by size according to worldwide sales in 1969. The Big-8 firms were Exxon, Mobil, Texaco, Gulf, Standard of California, Shell, Standard of Indiana, and Arco.

17. More than 130 firms participated in OCS lease auctions during the first twenty years. *See* S. Wilcox, Joint Venture Bidding and Entry in the Market for Offshore Petroleum Leases 66 (March 1985) (unpublished Ph.D. dissertation, University of California, Santa Barbara, available in UCSB Library).

18. Mead, *supra* note 2, at 41, found that Big-8 firms earned *lower* after tax rates of return than the average for all firms on the first 1,223 OCS leases issued in the Gulf of Mexico.

among the largest oil companies in 1975, a ban that was later endorsed by Congress in the Energy Policy and Conservation Act.[19]

The effect of joint bidding on the size of winning bids involves more complexities than critics of the system have suggested. However, while it might appear that joint bidding facilitates coordination among bidders and thus reduces the number of bids for each lease, it is true also that joint bidding permits smaller firms to enter the OCS lease market by allowing them to spread risk across a larger number of leases. Even among larger firms, joint bidding may increase the number of bids cast by encouraging more firms to participate in bidding for the most expensive OCS tracts. Studies of the effect of joint bidding on the average number of bids for OCS leases have shown that joint bidding is prone to increase, rather than decrease, the number of bids.[20] Taken together, these considerations lead us to hypothesize that joint bidding would have a small but positive effect on the size of winning bids and that this effect would be most strongly observed in cases involving the most expensive leases, particularly drainage leases.

Amount and Distribution of Information Available to Bidders

1. Access to special information (NBOR and NNBOR)

Leases offered for sale on the OCS are of two types: wildcat and drainage. Wildcat tracts are located in unexplored, undrilled areas. There are no well drilling data or other positive indicators for these areas which would permit bidders to accurately estimate the potential productivity of these leases. Drainage leases, on the other hand, are located near proven deposits. Well drilling data and perhaps production data exist which lead informed parties, including the USGS, to believe that a proven deposit extends into the drainage tract. The state of knowledge regarding the geology underlying a drainage tract is not uniform among all potential bidders. Firms which are lessees of adjacent tracts, or neighbors, have more knowledge than firms in general. But even non-neighbor firms may be presumed to know more about a drainage tract than is known by firms in general about any given wildcat tract, since part of the knowledge gained by neighbor firms in their exploratory activities on adjacent tracts is picked up by other firms from official and non-official reports of lease activity.

Economic theory suggests that firms with superior information should

19. Pub. L. No. 94-163.

20. Markham, *The Competitive Effectives of Joint Bidding by Oil Companies for Offshore Leases*, in INDUSTRIAL ORGANIZATION AND ECONOMIC DEVELOPMENT 116 (J. Markham & G. Papanek, eds. 1970); and Dougherty & Lohrenz, *Statistical Analysis of Solo and Joint Bids for Federal Offshore Oil and Gas Leases*, 18 SOC. PET. ENG. J. 87 (1978).

be expected to make higher bids for drainage tracts than other firms, on average, because the risk factors facing better-informed firms would be lower. Theory suggests, in addition, that non-neighbor firms bidding on drainage tracts would make higher bids than firms in general would make for wildcat tracts because the average quality of drainage leases is higher and the degree of uncertainty regarding their productive potential is lower.

To test these hypotheses, proxy variables for neighbor and non-neighbor bids for drainage leases are used in Model 1 below to distinguish these bids from bids made by firms generally for wildcat leases. It is hypothesized that neighbor bids should have a positive impact on the size of the winning bids as compared to wildcat bids.[21]

2. Percentage share of past leases won (PSHPASTL)

An important factor affecting the pattern of bidding for leases is the experience of the bidder in prior lease sales in the Gulf of Mexico. Firms which have acquired acreage in prior lease sales would most likely have a better knowledge of the underlying geology of the Gulf of Mexico and the nature of competition among bidders than firms with less experience in bidding and exploring. Under this interpretation, accumulated experience is an asset to a bidder. Less experienced bidders have to pay a premium, partly in the form of higher bids, in order to acquire this asset. Furthermore, to the extent that early experience in bidding for and developing OCS leases was either disappointing or more highly rewarding than expected, firms with a larger share of winning bids in prior lease sales would be most likely to correct for this experience in framing their current bids.

Our study of rates of return earned by firms which were winning bidders in 1954–59 OCS lease sales shows that these rates of return were below normal, but that rates of return generally rose in subsequent lease sales.[22] Thus, it is hypothesized that firms with a larger percentage share of leases awarded in past lease sales would tend to make lower winning bids for leases won in current lease sales, or that the correlation between the variable PSHPASTL and the high bid should be negative over the studied time period.[23]

21. The neighbor tract was identified by using pre-sale geological and engineering evaluations of tracts offered for sale maintained by the USGS. A neighbor bid was defined as any bid for the drainage tract which included at least one of the neighbor lessees, the operator of the neighbor tract, or any member of a utilization agreement which the neighbor tract was part of. These are the parties who are entitled to share drilling data generated on a lease.

22. Mead, *supra* note 2, at 45.

23. The value of PSHPASTL is undefined for the first lease sale (10-13-54). The 90 leases issued in this sale are, therefore, used to compute the value of PSHPASTL in the second lease sale, but are not included as observations for estimating the parameters of the regression models. The value of PSHPASTL is adjusted for each bidder after each lease sale.

Other Variables Used to Distinguish Among Winning Bids

1. Sale specific characteristics

This study is based upon the experience of bidding in the first seventeen OCS lease sales held in the Gulf of Mexico from 1954 to 1969. It is likely that the nature of the underlying geology of tracts offered for sale, demand and cost conditions, and regulatory constraints have varied to some extent from lease sale to lease sale.[24] To measure those effects on high bids which are lease sale specific, proxy variables, or dummy variables are used. Dummy variables are used in regression analysis because many of the independent variables of interest cannot be measured on a continuous scale, such as the differences imparted to high bids as a result of the differences in lease sale date. Dummy variables which distinguished each of the fourteen lease sales held after 1955 from the "base case" representing leases sold in the three 1954–55 sales are used in Model 2. The NBOR and NNBOR variables must be excluded from Model 2 for the reason that the lease sale dummy variables already separate most of the leases sold into categories of "wildcat" or "drainage."

2. Variables used to measure interactions among explanatory factors

Models 1 and 2 employ dummy variables such as BIG801 and JOINTO1 to distinguish between bidders on the basis of firm size or type of bidding arrangement. Model 3 employs combinations of dummy variables in such a way as to permit investigation of the effects on high bids of interactions among these variables. Using Model 3, for example, it is possible to determine whether Big-8/wildcat/solo bids differ significantly from non-Big-8/wildcat/solo bids. This kind of detailed investigation of differences among bids would not be possible using Models 1 and 2.

It should be noted that the three models reported in this paper have been estimated from the same dataset, that is, all OCS oil and gas leases issued in the Gulf of Mexico over the time period 1954–69. These models should not be interpreted as competing versions of the analysis, but rather as different formulations intended to identify different economic relationships or to provide greater detail in analysis. An explanation of the results of the regression analysis, for each of the regression models used, is presented in the section which follows.

24. Regressions using interest rates, product prices, and an index of oil field equipment costs were tested but rejected, for the reason that these variables were highly collinear and showed little variation from lease sale to lease sale.

RESULTS OF THE REGRESSION ANALYSIS

Model 1

Model 1 is formulated to reflect the most basic economic relationships discussed in the preceding section. Nine of the ten independent variables included in the model are statistically significant; the non-significant variable is JOINT01. The fact of non-significance means that joint bidders paid neither more nor less than solo bidders for the leases in our sample. The other independent variables performed according to theoretical expectations, with the exception of BIG801. This variable is significant and positive, indicating that larger firms paid more for leases than did smaller firms, *ceteris paribus*. This result suggests that large firms may be better able to carry risk or that they may have some comparative advantage in lease development. It is possible, also, that large firms were simply more careless in formulating bids and that they ended up consistently overbidding for leases as compared to smaller firms, but this is unlikely. This question is explored more fully in the discussion of Model 3, below.

MODEL 1

Dependent Variable: The Natural Logarithm of High Bid
$R^2 = .6587$

Independent Variables	*Coefficient Estimate*	*t-value*
INTERCEPT	6.711	12.80*
LNPVP	0.009	2.11*
LNWELL24	0.498	10.86*
LNACRES	0.703	10.93*
LNWATDEP	−0.096	−2.28*
LNNBIDS	1.193	31.21*
BIG801	0.276	3.47*
JOINT01	−0.005	−0.07
NBOR	1.443	10.28*
NNBOR	1.089	7.14*
PSHPASTL	−0.039	−5.27*

*Significant at the 5 percent level (two tailed test).

Other conclusions emerging from examination of Model 1 are these: the size of winning bids rises as the number of competing bidders rises and as the perceived quality of leases improves (LNNBIDS, LNPVP, LNWELL24, and LNACRES are all significant and positive). As prospective costs of development rise, bidders pay less (LNWATDEP is sig-

nificant and negative). The amount of information possessed by bidders is an important factor in determining the size of winning bids. Firms with greater experience in OCS bidding (PSHPASTL) or with better information about the lease being offered for sale (NBOR and NNBOR) are able to factor this information into the formulation of their bids. As firms accumulate more information by acquiring acreage, they are less likely to overbid for leases (PSHPASTL is significant and negative). On the other hand, bidders paid more for leases as their knowledge of the specific geology of the lease increased. Neighbors paid more for drainage leases than non-neighbors, and non-neighbors paid more for drainage leases than was paid on average by all bidders for wildcat leases.

Model 2

Model 2 explicitly introduces the time element by including a set of dummy variables to represent individual lease sales. This model is primarily motivated by the question of whether the basic relationships identified in Model 1 are affected if time of lease sale is explicitly accounted for. The lease sale variables included in Model 2 capture any changes in levels of high bids which are explained by changes in prices, costs, or bidder expectations which occurred over time.

As is necessary in employing lease sale dummy variables in the model, one group of leases (those sold in the 1954–55 lease sales) is included in the "base case" which provides the basis for comparison to the other lease sales.

MODEL 2

Dependent Variable: The Natural Logarithm of High Bid
$R^2 = .7172$

Independent Variables	*Coefficient Estimate*	*t-value*
INTERCEPT	5.516	10.49*
LNPVP	0.015	3.93*
LNWELL24	0.429	10.10*
LNACRES	0.800	12.32*
LNWATDEP	−0.078	−1.85
LNNBIDS	1.120	30.50*
BIG801	0.237	3.19*
JOINT01	0.072	1.08
PSHPASTL	−0.020	−2.77*
SP52659	−0.934	−4.52*
S081159	2.022	9.42*
S022460	0.378	3.63*

Independent Variables	*Coefficient Estimate*	*t-value*
S031362	−0.017	−0.18
S031662	−0.001	−0.01
S100962	1.955	6.61*
S042864	1.212	5.92*
S032966	1.661	7.44*
S101866	1.144	6.01*
S061367	0.533	4.97*
S052168	0.759	6.68*
S111968	2.428	10.62*
S011469	1.557	7.51*
S121669	0.711	3.15*

*Significant at the 5 percent level (two tailed test).

Thus the first lease sale dummy variable, called SO52659 in Model 2, represents the sale held May 26, 1959. The coefficient estimate for this variable, which is negative and significant, should be interpreted to mean that the leases in this sale had significantly lower winning bids than were recorded for the leases sold in 1954–55, after taking account of the effects of the other variables in the model.

The sign and significance of the variables carried over from Model 1 are unchanged except for the variable representing water depth (LNWATDEP), which is no longer significant at the 5 percent level.[25] Thus, the essential conclusions from Model 1 are relatively unaffected by the pooling of time series and cross-section data, probably because the bidding environment over the sample period was very stable. Of the fourteen lease sales held between 1956 and 1969, eleven had significantly higher winning bids than were recorded in the 1954–55 sales, one had significantly lower winning bids, and two showed no significant change.

Model 3

Model 3 represents a refinement of Model 1 in which the variables relating to neighbor and non-neighbor status (NBOR and NNBOR) are replaced by seven new dummy variables representing the size of the winning bidder, the lease type, and the bid type. Using this formulation of the model, it is possible to determine, for example, whether Big-8/wildcat/solo leases commanded higher bids than non-Big-8/wildcat/solo

25. Each lease sale comprises tracts located within the same general level of water depth. Thus, when lease sale dummy variables are included in the model, these variables tend to pick up the effects of changing water depth causing LNWATDEP to lose much of its explanatory power.

leases. As noted earlier, the results shown for Model 3 must be interpreted relative to a "base case" which is non-Big-8/wildcat/solo leases (NB8WS). Looking at the interaction variables in Model 3, it is apparent that all but one of the alternative lease categories had higher levels of winning bids than the base case, NB8WS. Only non-Big-8/wildcat/joint leases (NB8WJ) were not significantly higher than the leases included in the base case. This result is consistent with the overall finding that joint bids are not significantly different from solo bids, when adjusted for the effects of other independent variables.

MODEL 3

Dependent Variable: The Natural Logarithm of High Bid
$R^2 = .6586$

Independent Variables	*Coefficient Estimate*	*t-value*
INTERCEPT	6.723	12.67*
LNPVP	0.009	2.10*
LNWELL24	0.502	10.88*
LNACRES	0.704	10.84*
LNWATDEP	−0.103	−2.43*
LNNBIDS	1.184	30.82*
B8WS	0.321	3.36*
B8WJ	0.248	2.89*
B8DS	1.506	8.72*
B8DJ	1.740	9.62*
NB8WJ	0.089	0.72
NB8DS	1.142	4.67*
NB8DJ	1.479	4.18*
PSHPASTL	−0.039	−5.12*

*Significant at the 5 percent level (two tailed test).

The base case reported in Model 3 is only one of the eight possible versions of this model, since each of the other seven interaction variables could have been used as the base case. For the sake of brevity, Model 3 has not been reproduced in each of its eight possible versions but, instead, the most important results from the eight versions are summarized in Table 1.[26] Each row in Table 1 represents a base case, while the numbers reported under the columns are t-values representing the sign and sig-

26. The R^2 for Model 3 and the sign and significance of all variables in the model except for the interaction variables remain unchanged in the eight versions of the model.

nificance of differences between the high bids for leases in the category represented by the column heading as compared to leases in the base case. Where the t-values are significant at the 5 percent level, a star is entered in the table. The results of the analysis using Model 3 follow.

1. Comparison of Big-8 with non-Big-8 bids

Only one category of Big-8 bids is shown to be significantly different from the same category of non-Big-8 bids: Big-8/wildcat/solo bids are significantly higher than non-Big-8/wildcat/solo bids.[27] Big-8 firms paid neither significantly more nor less than smaller firms when bidding jointly or when bidding alone for drainage leases. Non-Big-8 firms apparently perceive wildcat leases to be significantly more risky, at least when bidding alone, while Big-8 firms appear better able to carry this risk when bidding alone.

2. Comparison of drainage with wildcat leases

Bidders in every category paid more for drainage leases than they paid for wildcat leases. This finding conforms to theoretical expectations since drainage leases have much more promising geology (on average) and information concerning this higher geological and economic protential is widely communicated among bidders.

3. Comparison of joint bids with solo bids

Joint bidders paid neither significantly more nor less than solo bidders for any of the lease categories shown in Table 1. This finding lends support to the conclusion that joint bidding does not have anticompetitive effects on the levels of high bids for OCS leases.

To summarize the findings of the analysis using Model 3, Big-8 firms paid significantly more for OCS leases than non-Big-8 firms in only one category: wildcat/solo leases. Otherwise, the high bids of Big-8 firms were not significantly different from those of smaller firms. Drainage leases commanded significantly higher bids than wildcat leases for all categories of bidders and bidding forms. Finally, there was no significant difference between high bids submitted by joint bidders and those submitted by solo bidders.

27. Another study of the record of bidding by major and non-major firms in ten Gulf of Mexico OCS lease sales over a time period subsequent to that used in this study (1972-75) suggests that major firms paid neither more nor less than non-major firms for the wildcat tracts they acquired in these lease sales. While this study is not strictly parallel to ours for various reasons, the findings may mean that the willingness or ability of large firms to pay more for wildcat leases has not continued into the more recent period. *See* Millsaps & Ott, *Information and Bidding Behavior by Major Oil Companies for Outer Continental Shelf Leases: Is the Joint Bidding Ban Justified,* 2 ENERGY J. 71, 79 (1981).

TABLE 1

Model 3 (High Bid) with Varying Base Case

	B8WS	*B8WJ*	*B8DS*	*B8DJ*	*NB8WS*	*NB8WJ*	*NB8DS*	*NB8DJ*
1. B8WS		−.85.	7.74*	7.73*	−3.36*	−1.70	3.26*	3.23*
2. B8WJ	.85		7.44*	8.09*	−2.89*	−1.25	3.57*	3.36*
3. B8DS	−7.74*	−7.44*		1.11	−8.72*	−7.14*	−1.35	−0.7
4. B8DJ	−7.73*	−8.09*	−1.11		−9.62*	−8.09*	−2.15*	−.68
5. NB8WS	3.36*	2.89*	8.72*	9.62*		.72	4.67*	4.18*
6. NB8WJ	1.70	1.25	7.14*	8.09*	−.72		4.00*	3.80*
7. NB8DS	−3.26*	−3.57*	1.35	2.15	−4.67*	−4.00*		.81
8. NB8DJ	−3.23*	−3.46*	.07	.68	−4.18*	−3.80*	−.81	

i) Each row represents a base case; row 5 is the base case used in Model 3. t-values are given for differences in coefficients between the base case variable and the variable at the top of each row. A positive t-value implies that leases in the column category had larger LNHIGHBD values than leases in the base case (row) category after the effects of other explanatory variables have been accounted for (and conversely for negative t-values).

ii) An asterisk indicates that the difference between the column and row entry is significant at the 5% level (two tailed test).

CONCLUSIONS

This study has examined the record of bidding, development, and production of the first 1,223 OCS oil and gas leases issued in the Gulf of Mexico over the years 1954-1969. Multiple regression analysis of high bids for these leases indicates that bidding outcomes correspond closely to what would be expected from profit maximizing behavior under competitive conditions. Leases with better geological and economic prospects command higher bids; drainage leases receive significantly higher bids than wildcat leases. The thesis that bidding is based upon rational economic calculations is confirmed by the analysis.

There is no significant difference in levels of high bids submitted for drainage leases by large firms as compared to smaller firms. This is true whether the smaller firms are bidding solo or jointly. Large firms show no ability to preempt the market for drainage leases; smaller firms are equally able to take advantage of the superior level of information which is available concerning the prospects for drainage leases.

The same is not true for wildcat leases. Large firms submitted significantly higher bids than smaller firms when bidding alone for wildcat leases. Economic theory suggests that large firms may have an enhanced ability to bid alone for these leases because they are financially able to hold a larger portfolio of leases than smaller firms. In the absence of the joint bidding alternative, this advantage could lead to larger firms ob-

taining a disproportionate share of wildcat acreage. The joint bidding mechanism permits smaller firms to compete on an equal footing with large firms, however, at least with respect to the risk spreading factor.

Joint bidding in itself has no significant impact on the level of high bids. This is true whatever the size of firms comprising the joint bidding combine and whether the bids are cast for wildcat or drainage leases. Joint bidding facilitates entry by smaller firms into the OCS lease market; it also permits a larger number of firms to participate in bidding for the most expensive drainage leases. Thus it tends to equalize the advantage large firms might otherwise have, the ability to spread risk. There is no evidence that joint bidding has any anticompetitive effects on the OCS lease market.

Examination of the pattern of bidding for drainage leases reveals the important effects of superior information. Neighbors, or firms which have leased adjacent acreage and thus know much more about the underlying geology of the lease area, make significantly higher bids for drainage leases than do non-neighbors. Although drainage leases are, on average, more profitable to lessees than wildcat leases, the advantages of the superior information gained by wildcat lessees in bidding for adjacent leases sold in later drainage sales seems to be paid for in the premium price of wildcat leases. Thus while wildcat leases offer lower direct returns to lessees than do drainage leases, firms which lease wildcat tracts are later able to bid more advantageously in buying acreage adjacent to these wildcat tracts. The value of information obtained in previous OCS lease operations is demonstrated also in the fact that bidders with greater experience in purchasing OCS leases were able to capitalize on this experience in bidding for leases sold in later lease sales. The poor returns experienced by winning bidders in early OCS lease sales led these bidders to adjust their bid levels downward in later sales, relative to other bidders, raising the profitability of their OCS lease investment on average.

The evidence provided by the first seventeen OCS oil and gas lease sales in the Gulf of Mexico indicated that the traditional cash bonus bidding plus fixed royalty system of leasing public lands for resource development has produced results closely conforming to theoretical expectations for a competitive market. These results should be considered carefully before the federal government institutes any major revisions of the leasing policies to be used in future OCS lease sales.