Information and Bidding Behavior by Major Oil Companies for Outer Continental Shelf Leases: Is the Joint Bidding Ban Justified?

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INTRODUCTION AND BACKGROUND

The Energy Policy and Conservation Act (PL 94-163), signed into law in December 1975, forbade oil companies that produced the equivalent of 1.6 million barrels of oil per day (mbd) worldwide from bidding jointly for outer continental shelf (OCS) leases. The U.S. Department of the Interior adopted regulations to that effect. The Outer Continental Shelf Lands Act Amendment of 1978 (PL 95-372) modified the 1975 law. This amendment gives the Secretary of the Interior the power to conduct periodic reviews of production rates by petroleum

The Energy Journal, Vol. 2, No. 3

While the authors are solely responsible for the contents of this paper, we acknowledge the assistance and useful comments of Tom Bohannon, Ed Erickson, John Lohrenz, and three anonymous referees. A previous version of this paper was presented at a special conference sponsored by ORSA/TIMS in Williamsburg, Virginia (April 18, 1980). This version reflects some of the comments we received at that conference. This work was supported in part by a Summer Research Grant from Appalachian State University.

producers and to ban from joint bidding any person or firm that produced, during a prior six-month period specified by the secretary, an average of 1.6 mbd.[1] The eight oil companies currently affected by the ban are Exxon, Gulf, Mobil, Shell, Standard of Indiana, Standard of California, Texaco, and British Petroleum.[2] These majors may submit solo bids, or may bid jointly with other oil companies not subject to the ban.

The rationale for the ban was provided by a study conducted by Darius W. Gaskins, Jr., and Barry Vann (hereafter, G&V), which alleges that joint bids by major oil companies have anticompetitive effects outweighing any possible benefits (G&V, pp. 210–220). G&V begin by observing that a positive relationship exists between the number of bidders for a government OCS tract and the ratio of the high bid to the government's presale estimate of the tract value.[3] According to G&V, this relationship is explained by the information-gathering nature of the joint bidding process. Briefly, they argue that joint bidding by majors enables them to obtain information about where other majors will and will not bid; they assert that if one major is able to discover no interest among other majors for a given tract, it might lower its bid without affecting its likelihood of winning the tract. Hence, the anticompetitive attribute of joint bidding among majors, according to G&V, is that the information gained at the joint venture negotiations tends to allow majors to win tracts on more favorable terms than would otherwise be the case. G&V claim support for this hypothesis from the observation that the ratio of high-bid (the winning bid on any given tract) to government presale estimate is lower for majors than for any other category of bidders.[4]

The American Petroleum Institute (API) undertook a point-by-point

1. The secretary may authorize joint bidding by firms subject to the ban on lands that have extremely high-cost exploration or development problems and on lands where exploration and development will not occur unless exemptions are granted.

2. Henceforth, these companies will be collectively described as the "majors."

3. G&V presume that the ratio of high bid to government presale estimate is a measure of how well the bidder fared—the lower the better—or how well the government fared—the higher the better.

4. If firms are risk-averse, direct inferences may not validly be drawn from such an observation without taking into account the total amount at risk,—i.e., "exposed"—in the auction. Furthermore, as a result of their larger OCS holdings, major firms more often than minor firms will be bidding on drainage tracts adjacent to other owned tracts; an API study suggests that, in such cases, bids tend to be lower and that the likelihood of uncontested bids increases (Kobrin et al., 1977, p. 28). It should be noted that using the U.S. Geological Survey presale estimate of tract value in the denominator of the G&V ratio test may be incorrect since these estimates have a low correlation with actual values obtained from development. For a discussion of this point, see Dougherty and Lohrenz (1978).

critique of the G&V study,[5] and found computational flaws in its analysis. G&V omitted tracts from their calculations when USGS presale evaluations could not be found. Also, on tracts where the USGS had assigned negative values, G&V substituted zero evaluations. Finally, API concludes that G&V made computational errors in their hand calculations. API duplicated, via computer, the G&V procedures with the same data and found marked differences in the results. For example, as I found, the ratio of high-bid to USGS estimates for majors was higher than G&V indicated. When API repeated the procedure using all USGS estimates (and negative estimates rather than zero where indicated by the USGS), they found that the majors bid *more* relative to USGS estimates than nonmajors. This result is, of course, inconsistent with G&V's implication that bidding information advantages enable majors to win tracts on more favorable terms than nonmajors.

Furthermore, the study offers an alternative explanation for G&V's observation of a positive relationship between the number of bidders for a tract and the ratio of the high bid to the government's estimated value: there appears to be an unsurprising tendency for potentially more productive tracts (as measured by the government's presale estimates) to attract more bidders.

The API study conclusions are consistent with most major studies in this area, i.e., that joint ventures are procompetitive.[6] Yet, while the analytical dust settles, the bidding ban remains. Why? First, the political climate of the mid-70s was characterized by extreme citizen dissatisfaction with rising energy prices, gasoline shortages, and oil company profits. Lawmakers, in response to these public concerns, issued many regulatory policies directed toward constraining the activities of oil producers, especially the majors. The bidding ban was only one of these many policies, one for which the G&V analysis and subsequent House testimony provided a justification.

Second, the merits of the G&V empirical analysis aside, the G&V "information" hypothesis—that information gained at the joint bidding negotiation table is used by majors to increase the likelihood of winning on other tracts—evidently was persuasive to policymakers. Given the regulatory and political climate at that time, the idea of allowing major oil producers to sit down in the same room and discuss a joint venture probably was sufficient to convince policymakers to change the rules.[7]

5. Kobrin et al. (1977). A more recent study with further tests and stronger evidence against the ban's rationale is Sullivan and Kobrin (1978).

6. See Markham (1979); Erickson and Spann (1974); and Mead (1974)—but see also Mead (1967) and Dougherty and Lohrenz (1978).

7. In addition, along with the implementation of the joint bidding ban, a number of "unconventional" bidding systems have been instituted. These include royalty bidding

Our study is designed to focus directly on the G&V "information" hypothesis. G&V postulated that information gained during joint bidding negotiations is used to increase the *chances of winning* on other tracts. To our knowledge, no study has concentrated on this important aspect of the problem. In Section II we discuss the G&V model in more detail. Then, in Section III, we develop and test a model of the probability of winning an OCS lease tract as a function of G&V–type information, the number of competitors, the level of a bid relative to other competing bids, and other variables. Finally, Section IV discusses the policy implications of our study on the conduct of OCS lease auctions.

THE "INFORMATION" HYPOTHESIS

The "information" hypothesis G&V use to explain the observed positive relationship between the number of bidders for a government OCS tract and the ratio of the high bid to the government's presale estimate is described as follows:

> Companies X, Y, and Z attend a meeting to discuss the possibility of rendering joint bids for tracts A through G. Company X indicates that it is interested in bidding on tracts A, B, D, and G. Company Y wants to bid on B, C, D, and F. Company Z declares it is only interested in B, C, and E. This meeting may result in a joint bid for tracts B and D but it also indicates to Company X that it will receive no competition from Y or Z on tracts A and G, etc. (G&V, pp. 217–218).
>
> Since the major oil companies are likely to be interested in a large proportion of the tracts for sale, information as to their precise bidding intentions may be very valuable to rival bidders. For example, if one major is able to discover that there is no interest among other majors for a specific tract which it intends to bid for, it could lower its bid and win that tract on more favorable terms (G&V, p. 210).

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and such other innovations as fixed–net profit share bidding. For a specific analysis of fixed–net profit share bidding, see Council on Wage and Price Stability (1980). For a general analysis of the prospective performance of unconventional bidding systems relative to bonus bidding, see Ramsey (forthcoming), and McDonald (1979). The emergence of significant OCS royalty bidding roughly coincided with the joint bidding ban and both can be regarded as precursors of the trend toward unconventional bidding systems. Presumably, these innovations were introduced as mechanisms to correct perceived competitive imperfections in the bidding process.

However, examination of the suppositions raises several questions. Suppose Major A learns that Majors B and C are not interested in bidding jointly on a given tract. It is possible that B and C plan to submit solo bids on this tract or plan to bid jointly with other partners (major or nonmajor). Major A should not necessarily conclude that B and C will not compete on this tract. Also, there is a large number of other potential competitors (joint and solo, major and nonmajor) for a given OCS tract.[8]

In this study, we assume that any information a major gains from joint bidding negotiations with other major partners will be hoarded and used primarily in adjusting (downward) the major's solo bids. While it is possible that information gained from a group of potential joint venture partners might be shared with another group, we think this is unlikely. The mechanics would be difficult to manage, given the institutional characteristics of forming a joint bid. For example, the negotiations must be conducted publicly according to a highly structured format. Department of the Interior officials and lawyers are present to ensure that the participants adhere to the guidelines. Information sharing of the type we are investigating would be difficult to accomplish under such a regime. Also, given the large number of firms active in OCS lease sales, the ease of entry and the large number of potential competitors for any specific tract,[9] it is possible that transmissions of such information to other groups—were it technically possible and were it a part of a more general information transmission system—could work to the disadvantage of the transmitting firm.

Table 1 presents summary statistics for solo bidding by major and nonmajor firms for ten lease sales covering the period from December 1972 to July 1975.[10]

8. The average number of bids on a given tract was approximately five between 1972 and 1975, our period of study. The average number of bids per tract has been falling since 1975 and is now fewer than four. Over 125 firms are currently involved in OCS operations.

9. In 1960, approximately 65 separate firms either submitted solo bids or participated in joint venture bids in the Gulf of Mexico OCS lease sales. In 1974, the last year before the joint bidding ban on major firms, the total number of bidding participants was approximately 125.

10. This period covers lease sales just prior to the joint bidding ban. Most other studies have used early 1970 data. These tracts are almost exclusively wildcats except for the June 1973 sale, which included some drainage tracts. The July 1974 sale was a "junk" sale, i.e., a sale of tracts that had previously been offered for sale and for which no bids were received. All tracts are in the Gulf of Mexico. All data are restricted to tracts for which leases were issued by the government. The tracts for which the government refused the high bid are not considered.

Table 1. Solo Bidding Statistics for Major and Nonmajor Oil Companies

	Major Oil Companies					*Nonmajor Oil Companies*					*Majors Plus Nonmajors*				
Sales Date	N	W	$W\%$	Σn	$\bar{n}$	N	W	$W\%$	Σn	$\bar{n}$	N	W	$W\%$	Σn	$\bar{n}$
12-19-72	32	6	19	261	8.15	115	26	23	846	7.36	147	32	22	1107	7.53
6-19-73	11	3	27	88	8.00	84	7	08	710	8.45	95	10	11	798	8.40
12-20-73	18	5	28	90	5.00	117	26	22	674	5.76	135	31	23	764	5.66
3-28-74	44	15	34	227	5.16	71	10	14	424	5.97	115	25	22	651	5.66
5-29-74	47	16	34	245	5.21	78	24	31	361	4.63	125	40	32	606	4.85
7-30-74	7	5	71	9	1.29	6	4	67	13	2.17	13	9	69	22	1.69
10-16-74	71	28	39	218	3.07	63	28	44	185	2.94	134	56	42	403	3.01
2-04-75	91	57	63	224	2.46	13	7	54	38	2.92	104	64	62	362	3.48
5-28-75	48	25	52	137	2.85	23	14	64	63	2.86	70	39	56	200	2.86
7-29-75	44	20	45	187	4.25	36	15	42	123	3.42	80	35	44	310	3.88
Totals	413	180	44	1686	4.08	605	161	27	3437	5.63	1018	341	33	5123	5.03

Source: U.S. Department of Interior, USGS Conservation Division, LPR 5 Computer Tape (1977).
N = number of solo bids
W = number of solo bids won
$W\%$ = winning percentage = $W/N \times 100$
Σn = number of bidders
$\bar{n}$ = average number of bidders on tracts for which bids were entered

Majors won 44 percent of their 413 solo bids. Nonmajors won 27 percent of their 605 solo bids. Majors faced about three competitors, on the average, in their solo bids, while nonmajors faced a little over four and a half competitors.[11] The average number of bids on all leases issued during this period is approximately four (three competitors to each bidding firm, on the average, for each lease).

The higher winning percentage of the majors could be explained by the "information" hypothesis. Competing hypotheses include (1) more aggressive bidding by majors, e.g., bidding more on a more frequent basis, (2) facing a smaller number of competitors on the average (as shown in Table 1), and (3) luck (unlikely with this large a sample).

Table 2 presents summary statistics on the average bid per acre for solo bids by majors and nonmajors for the ten sales dates we examined. In seven of the ten lease sales, the average bid per acre (on all bids and on winning bids) was higher for majors than for nonmajors. This tends to suggest that majors offer more on their solo bids than do nonmajors.

It will be noted in Table 2 that the general trend in both "all bids" and "winning bids" is downward over time. There are a number of reasons why this may have occurred. First, during the period from which the data in Table 2 were taken, there were effective price controls on both oil and natural gas. Thus, OCS bids reflected both the existence of price controls and expectations concerning their future persistence and forms. Second, Gulf of Mexico OCS exploration in the federal domain began in 1954. By the end of the period examined, over 20 years of exploration had taken place. It is a well-known proposition that exploration activity tends to identify the most promising prospects first.[12] Thus, the downward trend in lease bids may also reflect the exploration maturity (general expectations of relatively smaller discoveries) of the Gulf of Mexico OCS. Third, in later years, a larger proportion of promising prospects have been in deeper water and farther from shore. Operations under these conditions are more costly and therefore have a depressing effect on lease bids. Fourth, OCS operating costs in general have been increasing, and this also would tend to depress lease bids. Finally, the period covered by Table 2 immediately preceded the repeal of percentage depletion. Percentage depletion was modified downward in 1972 for the classes of firms most active in OCS operations, and firms may have expected the final repeal that occurred at the end of 1975. These expectations would also tend to depress lease

11. From Table 1, $\bar{n}$ is the average number of bidders. The average number of competitors to each bidding firm is, of course, $\bar{n}-1$.

12. See, for example, Kaufman (1963).

Table 2. Average Bid per Acre for Major and Nonmajor Oil Companies (Solo Bids Only)

	Majors Average Bid/Acre		*Nonmajors Average Bid/Acre*		*Majors & Nonmajors Average Bid/Acre*	
Sales Date	*All Bids ($)*	*Winning Bids ($)*	*All Bids ($)*	*Winning Bids ($)*	*All Bids ($)*	*Winning Bids ($)*
12-19-72	2130	1546	1329	1798	1503	1751
6-19-73	1110	1165	1309	881	1286	967
12-20-73	2087	2699	886	1061	1046	1325
3-28-74	4045	5646	2133	3433	2865	4761
5-29-74	1416	1659	1234	1393	1302	1500
7-30-74	107	91	427	491	255	269
10-16-74	1153	1706	1525	1744	1328	1725
2-04-75	302	366	194	189	289	347
5-28-75	505	561	244	329	420	478
7-29-75	528	676	195	232	378	486

Source: U.S. Department of Interior, USGS Conservation Division, LPR 5 Computer Tape (1977).

bids. All these factors are compounded with price expectations, and an evaluation of the net impacts is beyond the scope of this article. Nevertheless, the trend of lease bids shown in Table 2 is not inconsistent with the general economic environment in which these bids were being determined.

The fact that majors' bids tended to be higher than nonmajors' bids is not necessarily the reason majors won a higher percentage of their solo bids. The higher percentage may be due to other conditions such as the majors' tendency to bid on more valuable tracts than the less wealthy or less geophysically sophisticated nonmajors. To allow for this phenomenon, some measure of the potential value of the tract is needed.

The USGS presale estimate is a good candidate. However, this estimate suffers from two major defects. First, the correlation between USGS presale estimates of tract value and the actual bids on a tract is very low.[13] Second, for the 1972–1975 period that we studied, there are a considerable number of tracts for which no presale estimate was made. Therefore, we rejected the measure in favor of using the geometric mean of all bids on a tract as a consensus measure of what the bidders thought of the potential value of a tract. The use of the geometric mean rather than the arithmetic mean is due to the tendency of the bids to be log-normally distributed.[14] The ratio of a given bid on a tract to the geometric mean of all bids on the tract (relative bid) is a measure of how a firm bid relative to the tract's potential value (as viewed by all bidders).[15]

In Table 3, the average relative bid for winning solo bids is displayed for each of the ten lease sales we examined. The average relative bid by majors is higher in five of the ten sales, equal on the May 1974 sale, and lower on the other four. The weighted average relative bid over all ten sale dates is slightly lower for majors, 1.77 versus 1.95. This suggests that majors and nonmajors are tendering equally competitive bids overall. The analysis in Tables 2 and 3 further emphasizes the necessity for a tract-by-tract analysis of bidding, and shows that summary statistics that average over a number of tracts can be very misleading.

If one is to test the effect of information on the likelihood of winning an OCS tract lease, one must develop a function to measure the relative

13. See Dougherty and Lohrenz (1978).

14. For an in-depth discussion of the distribution of bids, see Pelto (1971).

15. There are flaws in this measure also. For example, the firms who chose, for whatever reason, not to bid on this tract are excluded. They, the nonbidders, may have thought the tract was worthless, but they may also have chosen not to bid on a particular tract because of their estimate of the number of potential competitors.

Table 3. Average Relative Bid for Major and Nonmajor Oil Companies (Winning Solo Bids Only)

Sales Date	*Majors*	*Nonmajors*
12-19-72	2.78	2.97
6-19-73	1.01	1.17
12-20-73	3.23	1.74
3-28-74	1.98	1.51
5-29-74	2.43	2.44
7-30-74	1.03	1.82
10-16-74	1.40	1.58
2-04-75	1.49	1.30
5-28-75	1.65	1.48
7-29-75	2.15	1.88

Source: U.S. Department of Interior, USGS Conservation Division, LPR 5 Computer Tape (1977).

Note: The relative bid is the ratio of the bid to the geometric mean of all bids on a tract. The average relative bid for winning bids by majors and nonmajors is displayed by sales date.

Table 4. Joint Bidding Behavior by Major Oil Companies

Company	*Number of Solo Bids*	*Number of Joint Bids with Other Majors*	*Number of Different Majors with Which Joint Bids Tendered*
Exxon	132	55	2
Gulf	31	55	4
Mobil	20	151	6
Shell	94	21	2
Standard of Indiana	49	168	5
Standard of California	61	106	4
Texaco	26	25	3
British Petroleum	0	0	0

Source: U.S. Department of Interior, USGS Conservation Division, LPR 5 Computer Tape (1977).

amounts of information gained by majors at the joint bidding table. According to G&V's hypothesis, one can obtain this type of information by talking to as many different major competitors as possible, and by discussing with each as many different tracts as possible. Table 4 exhibits some summary statistics on joint bidding behavior by majors for the period under study.

According to the "information" hypothesis, Mobil and Standard of Indiana should have more information than Shell and Texaco. Mobil tendered only 20 solo bids during the period (winning 11). Shell, with apparently little "information," bid 94 times (winning 48). Exxon, without nearly as much joint bidding experience as Mobil, Standard of California, or Standard of Indiana, was the most active solo bidder.

The data in Table 4 offer little support for G&V's hypothesis regarding the relationship between joint bidding experience and the frequency of solo bids (or the probability of winning a solo bid). One interpretation of G&V's hypothesis is that those firms most active in gathering information about the tract-by-tract evaluations and bidding intentions of potentially rival firms would be among the most active firms in solo bidding on tracts that the information-gathering process reveals are of little interest to competitors. Instead, many of the most active solo bidders are relatively inactive in the information-gathering process. The information in Table 4 suggests that the joint bidding process exists for reasons other than those that G&V allege,[16] but a more formal model of the generation and use of information can be developed.

THE PROBABILITY MODEL AND EMPIRICAL RESULTS

The objective of this section is to develop and test a model of the probability of winning a given OCS tract by a major oil firm.

In addition to the number of bidders competing for the tract and the competitive posture of the bidder in question, G&V hypothesize that information obtained in joint bidding negotiations increases the probability of winning. The literature discussed in Section I also suggests that competing bids that involve majors (whether solo or jointly with other majors or nonmajors) may be more competitive than bids involving only nonmajors. Thus, we hypothesize the following model for solo bids by major oil companies:

$$P(W) = f(N, B, I, S, M) \tag{1}$$

16. In addition, the available analyses of the rate of return to Gulf of Mexico exploration, development and production operations indicate that companies active on the OCS earn no more than their corporate cost of capital. See Jones, Mead, and Sorensen (1979). The study is a comprehensive review of *all* 1223 leases issued between 1954 and 1969. The authors conclude: (1) the federal government has received more than a fair market value for its leases; (2) the OCS lease market is effectively competitive; (3) large firms have not received leases at less than fair market value (their rate of return is actually lower than the average); and (4) there is no evidence that joint bidding has restrained competition. Also, see Lohrenz (1978); Jones, Mead, and Sorensen (1978); and Sullivan and Kobrin (1978). These studies too are in general inconsistent with G&V's information hypothesis.

where $P(W)$ = probability of winning a tract
N = number of bids on the tract
B = a measure of the competitiveness of a firm's bid on a tract
I = "information" gained from joint venture partners
S = number of competing solo bids on a tract by other majors
M = number of competing joint bids on a tract involving at least one major

We expect:

$$\frac{\partial[P(W)]}{\partial N} < 0 \tag{2}$$

i.e., the larger the number of bidders, the lower the probability of winning.

$$\frac{\partial[P(W)]}{\partial B} > 0 \tag{3}$$

i.e., the higher a firm bids relative to competing bids on a tract, the higher the probability of winning.

$$\frac{\partial[P(W)]}{\partial I} > 0 \tag{4}$$

This is the G&V "information" hypothesis.

$$\frac{\partial[P(W)]}{\partial S} < 0 \quad \text{and} \quad \frac{\partial[P(W)]}{\partial M} < 0 \tag{5}$$

These variables are included to differentiate between a competing bid involving a major (joint or solo) and a competing bid not involving a major.

The binary nature of the dependent variable (1 = win, 0 = lose) is consistent with an estimating equation in logit form:[17]

$$\log\left[\frac{P}{1-P}\right] = \beta_0 + \beta_1 N + \beta_2 I + \beta_3 B + \beta_4 S + \beta_5 M + e \tag{6}$$

where $P(W)$ has been changed to simply P to ease the exposition. The dependent variable in equation (6) is the logarithm of the odds for winning a tract.

17. For a discussion of the problems created by a binary dependent variable and the logit solution, see Pindyck and Rubinfeld (1976).

The variable N is simply the number of competitors bidding on a given tract.

In specifying the I variable, we chose to assume that G&V–type "information" is a positive function of the number of joint bids a given major tendered with other majors on a given sales date. For example, for the December 19, 1972 sale, Standard of Indiana made nine joint bids with other majors (six with Standard of California and three with Shell). Thus, $I = 9$ for all Standard of Indiana solo bids on this date. Exxon, on the other hand, made no joint bids with other majors for this sale ($I = 0$). Therefore, we are explicitly assuming that Standard of Indiana gained more information from joint bidding negotiations than did Exxon, i.e., more information of the type G&V hypothesized is revealed by the number of joint bids tendered with other majors.

The B variable in equation (6) is designed to measure how high a firm is bidding relative to competing bids on a given tract. Several quantitative measures were considered. First, the ratio of the actual bid to the USGS presale estimate is a measure of a firm's level of bidding. However, the presale estimate suffers from the defects discussed in Section II (low correlation with actual value of a tract, missing estimates). Second, the ratio of the bid to the geometric mean of all bids on a tract (as discussed in Section II) could be considered a measure of bidding strength. However, this measure is a poor candidate in a model where the dependent variable is binary. The reason is that if this ratio is less than one, the bid is automatically a loser regardless of its value along the zero-to-one continuum (this ratio is less than one for approximately one-half of the 413 observations). Third, Dougherty and Lohrenz (1977) have developed and tested a measure called "bidding bias" to characterize the competitive posture of an OCS bidder.[18] Their measure, f_B, is the fraction of all other bids on tracts a firm bid on that are lower than the bidder's bid. For example, Exxon submitted 13 bids on the March 1972 sale and won none. On these 13 tracts Exxon faced a total of 136 competing bids. Of these, 77 bids were higher than Exxon's, and 59 lower. Therefore, f_B for Exxon on this date is 0.43 (59 divided by 136). For all ten sales analyzed in this article, Exxon submitted 132 bids, and faced 497 bids by competitors for these 132 tracts; 243 of the 497 bids were lower than Exxon's bids ($f_B = 0.49$).

Table 5 displays the f_B measure for majors as a group. For the ten sales dates analyzed, the f_B for majors was 0.53.

The strongest bidders among the majors (Texaco, $f_B = 0.73$; Mobil, $f_B = 0.59$; and Gulf, $f_B = 0.64$) won 55 percent of their bids (42 wins in 77 bids). This group bid high relative to the competition, but did

18. Also see SAD Section Report (1976).

Table 5. Majors as a Group (Solo Bidding)

Sales Date	N	W	$W\%$	Σn_c	$\bar{n}_c$	f_B
12-19-72	32	6	0.19	229	7.15	0.49
6-19-73	11	3	0.27	77	7.00	0.36
12-20-73	18	5	0.28	72	4.00	0.67
3-28-74	44	15	0.34	183	4.16	0.52
5-29-74	47	16	0.34	198	4.21	0.52
7-30-74	7	5	0.71	2	0.29	NA
10-16-74	71	2	0.39	147	2.07	0.47
2-04-75	91	57	0.63	133	1.46	0.51
5-28-75	48	25	0.52	89	1.85	0.54
7-29-75	44	20	0.45	143	3.25	0.70
Totals	413	180	0.44	1273	3.08	0.53

Source: U.S. Department of Interior, USGS Conservation Division, LPR 5 Computer Tape (1977).

N = number of solo bids
W = number of solo bids won
$W\%$ = winning Percentage = W/N
Σn_c = number of competing bids by other firms
$\bar{n}_c$ = average number of competing bids by other firms
f_B = measure of the bidder's competitive posture

not bid on a solo basis very frequently. Their 77 solo bids constitute only 18.6 percent of the total solo bids by majors during the period being analyzed.

Exxon, Shell, Standard of Indiana, and Standard of California were, on the average, middle-of-the-road bidders (f_B = 0.49, 0.47, and 0.48 respectively). They won 41.1 percent of their solo bids (138 wins in 336 bids).[19]

Of these three measures, the Dougherty–Lohrenz technique is preferred over the other two as an overall quantitative measure of the competitive posture of a bidder for a given sale. The f_B calculation summarizes a bidder's competitive posture while avoiding the quantitative problems posed by a ratio of the actual bid on a tract with the presale estimate or the geometric mean (see previous discussion).[20]

19. Dougherty and Lohrenz (1977) describe a bidder as "aggressive" if $f_B > 0.5$, "conservative" if $f_B < 0.5$, and "unbiased" if $f_B = 0.5$. Differences in this measure among bidders may be due to many other factors that have little, if anything, to do with a firm's attempt to be aggressive. For example, informational asymmetry, tract location, or the firm's wealth could cause f_B to vary among bidders. However, it is a good proxy measure for the level of a firm's bidding regardless of the reasons for the size of its bid relative to competing bids. An appendix to Table 5, listing f_B's for individual majors by sales date, is available from the authors.

20. In the estimation of equation (6) that follows (see equation (7) below), the variable B is quantified as the average f_B for a bidder on that sales date. For example, as discussed in the text, $B = 0.43$ for each of Exxon's 13 bids on the March 1972 sale. A similar calculation is made for the other majors for each sale.

The variables S and M are designed to capture the types of competing bids a major faces when it submits a solo bid. S is the number of competing solo bids by other majors on the tract in question; $S = 0$ if no other majors make solo bids on a tract. S can be 1, 2, and so on, depending on how many other majors also submitted solo bids on the tract.

The variable M is similar to S and describes a competing joint bid that involves at least one major. M can be 0, 1, 2, and so on, depending on the situation.[21]

Estimation of equation (6) using solo bidding data[22] for majors for ten lease sale dates (December 19, 1972, through July 29, 1975) yielded the following results:

$$\begin{aligned}\log\left[\frac{P(W)}{1-P(W)}\right] = &- \underset{(0.39821)}{0.72644} - \underset{(0.10380)}{0.58671N} + \underset{(0.77631)}{3.85312B} \\ &- \underset{(0.01260)}{0.01716I} - \underset{(0.21381)}{0.10376S} + \underset{(0.18428)}{0.07361M}\end{aligned} \qquad (7)$$

The numbers in parentheses are standard errors. The overall regression is statistically significant (chi-square = 145. 73 with 5 degrees of freedom; the probability of a chi-square of this value occurring by chance is less than .0001).[23]

The "information" variable, I, is not statistically different from zero (chi-square = 1.38; P = .24). Thus, the G&V hypothesis of a positive and significant sign on the "information" variable coefficient was not found in this model.[24]

21. Several authors have argued that joint bids by majors are substitutes for separate bids and, as a result, that they diminish the number of bids per tract, competition for leases, and the size of bonus payments (see Gaskins and Vann; and Wilcox, 1975). If this assertion were true, N and M would be correlated and the estimation of equation (6) would be biased. However, a number of analysts (Dougherty and Lohrenz, 1978; Sullivan and Kobrin, 1978; Markham, 1979) have disproved this allegation. Therefore, we are confident of the inclusion of N and M in equation (6).

22. Equation (6) was estimated using the LOGIST Subroutine in the 1979 version of SAS (Statistical Analysis System). The specifics of this procedure are found in SAS Institute, Inc (1979). The units of observation are the 413 solo bids by majors during this period.

23. The number of degrees of freedom in a logit estimation of this type is equal to the number of independent variables (6) minus one.

24. Four alternate specifications of I were entered in the equation (6) estimation. They were: (1) the number of different major joint venture partners a given major submitted joint bids with on a given sale, (2) the product of number of joint bids and the number of different joint major partners, (3) the logarithm of (2), and (4) the logarithm of our original specification of I. None was statistically different from zero. None materially affected the sign, magnitude, or statistical significance of the coefficients on the other variables.

The negative and statistically significant (chi-square = 76.34, P = .0001) coefficient on N, the number of competitors, was expected. The interpretation of the individual estimated parameters must be conducted with care since the dependent variable is the logarithm of the odds of winning, not the actual probability. For example, if the number of bidders on a tract increases by one, the logarithm of the odds on winning decreases by 0.58671. To interpret the effect of a change in N, we must solve for the change in the probability of winning, ΔP, as follows:

$$\Delta \log \left(\frac{P}{1 - P} \right) = - 0.58671 \Delta N \tag{8}$$

For any variable x, $\Delta \log x \approx \Delta x / x$, and $\log(x/y) = \log x - \log y$. Therefore, (8) can be written as:

$$\Delta \log \left(\frac{P}{1 - P} \right) \approx \left(\frac{1}{P} + \frac{1}{1 - P} \right) \Delta P = \left[\frac{1}{P(1 - P)} \right] \Delta P \tag{9}$$

Since $\Delta N = 1$,

$$\Delta P \approx -0.58671[P(1 - P)] \tag{10}$$

The curious result is that the change in probability is a function of the probability itself. We use equation (10) to form the following table:

Prior Probability of Winning	Change in Probability of Winning Due to Increasing the Number of Bidders by One
20%	− 9.4%
30	−12.3
40	−14.1
50	−14.7
60	−14.1
70	−12.3
80	− 9.4

Similar manipulation of the positive and statistically significant (chi-square = 24.96, P = .0001) B variable yields:

Prior Probability of Winning	Change in Probability of Winning Due to an Increase in B of 0.10.[25]
20%	+6.2%
30	+8.1
40	+9.2
50	+9.6
60	+9.2
70	+8.1
80	+6.2

For every additional bidder for an OCS tract, the probability of a major winning that tract with a solo bid is reduced by approximately 10 to 15 percent. Similarly, becoming more aggressive in bidding posture (as measured by a 0.10-increase in B) will increase the probability of winning by approximately 6 to 10 percent.

The "major" competition variables, S and M, were not statistically significant. This suggests that a competitor must be taken seriously, whether major or nonmajor. This is not a surprising result, given the large proportion of leases won by nonmajors.[26]

Finally, do the results make sense? Is there any a priori quantitative expectation mirrored by the statistical results summarized by equation (7)? Yes. For example, what coefficient might we expect on N, the number of bids? Suppose $B = 0.5$ for all bidders (the average B in this study is 0.53). If so, $P = 1/N$. This result is used to construct the following table:

N	Log (base e) $\left[\frac{P}{1-P}\right]$	
1	∞	
2	0	
3	-0.69	slope = -0.55
4	-1.10	
5	-1.39	slope = -0.35
6	-1.61	

25. $\Delta P \approx 3.85312[P(1-P)]\Delta B$. $\Delta B = 0.10$.

26. The joint bidding ban restricts the ability of major oil companies to risk-pool by forming joint bids with other majors. If these firms are risk-averse, they will lower their bids, probably win less frequently, and thus reduce the government's return on the public land. This suggests that we should extend our analysis to cover lease sales that have occurred subsequent to the ban. However, the intent of the present analysis is to examine the behavior of major oil companies during the period leading up to the ban, to draw inferences from that behavior, and to determine whether the ban was justified

Here one would expect a coefficient with respect to the number of bids in the range -0.35 to -0.55: the average number of bids in the population we studied is approximately four (see Table 1).

Also, the change in the probability of winning due to a change in the number of bidders (N) or a change in the competitive posture of the bidder (B) reported above are in close agreement with the work of Dougherty and Lohrenz (1977). These authors make forecasts similar to ours using a theoretical expectations model, and they obtain results of the same order of magnitude.

Policy Implications

The joint bidding ban on major oil companies was an administrative and legislative initiative that occurred in the political climate surrounding energy policy issues during the 1970s. The empirical support for this ban was provided by G&V's analysis. Others have demonstrated that the execution of G&V's empirical tests of their hypothesis were seriously flawed and at variance with most other analyses of the OCS bidding process.[27] In addition, G&V's hypothesis is not consistent with simple descriptive tabulations of joint and solo bidding activity and with measures of the rates of return that participants have earned in Gulf of Mexico OCS exploration, development, and production operations.[28] Nevertheless, no specific test of the G&V "information" hypothesis exists.

Equation (6) develops a specification that explicitly incorporates the G&V hypothesis into the determination of the probability that a bid will be successful. Equation (7) tests the G&V information hypothesis using LOGIT formulation. Neither the G&V information variable (I), as specified here, nor other variables (S and M) that relate to the types of firms that are competitors for specific tracts are statistically significant. These results are very robust with respect to alternative specifications of the information variable. The explanatory power of equation (7) is very high, and the principal contributions to this power are made by the variable that precisely specifies the number of com-

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on the basis of that evidence. Furthermore, the policy implications of an extended analysis are nil. For example, suppose the probability of winning by major increases (or decreases) during the post-ban period. What would this suggest with regard to the policy? Very little, for there is no method to determine the socially optimum winning frequency for a major or any other oil company.

27. See notes 4, 5, and 6.
28. See Table 4 and note 16.

petitors for a particular tract (*N*) and the variable that generally identifies various aspects of bidding behavior and results (*B*). Both variables are highly significant.

On the basis of the analysis presented above, G&V's information hypothesis must be judged lacking in empirical content. In addition, the coefficients and significance of the variables that relate to types of competitors (*S* and *M*) suggest the proposition that all competitors are effective. The trend of legislative and administrative events that began with the joint bidding ban has continued with the introduction of various "unconventional" bidding techniques such as royalty bidding and fixed–net profit share bidding. An analysis of these bidding systems must await the accumulation of data on their results, and is therefore beyond the scope of the work reported here. However, to the extent that these "unconventional" bidding systems are meant to be mechanisms for correcting anticompetitive bidding abuses of the traditional bonus bid, the rejection of G&V's information hypothesis by our analysis suggests that these new systems may be unnecessary.

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