
NATURAL RESOURCES JOURNAL

Volume 8
Issue 4 *Oil Shale Resources; Fall 1968*

Fall 1968

Competitive Bidding for Mineral Leases

Robert F. Rooney

COMPETITIVE BIDDING FOR MINERAL LEASES*

ROBERT F. ROONEY†

Under the Mining Act of 1872[1] federal government lands could be claimed for mining, with title ultimately passing to the owner of the claim if certain conditons were met. The Mineral Lands Leasing Act of 1920[2] removed certain minerals from the list of minerals which could be claimed and substituted mineral leases, similar to those issued by private landowners, for claiming. Several methods have been used for allocating these leases to competing parties, including first-come-first-serve, lottery, and competitive bonus bidding. Competitive bidding is generally accepted as the procedure best protecting the public interest in government-owned mineral lands.

The essence of competitive bidding is that the landowner defines the tract of land to be leased and specifies the level and nature of all but one of the lease terms, leaving one of the lease terms unspecified in amount. For example, in competitive bonus bidding the landowner specifies the level of the royalty rate, rental terms, and the environmental values to be maintained. The landowner then awards the lease to the firm bidding the highest bonus. The bonus need not be selected as the bidding variable and in rare instances two variables have been selected as the bidding variables. In the latter case, however, selecting the winning bidder is more ambiguous than when bidding is restricted to one variable.

Federal and state government revenues from competitive bonus bidding for offshore oil and gas leases have exceeded two billion dollars in the past few years. These high revenues provide major incentives for governments to use competitive bonus bidding to allocate mineral leases, especially in periods of budget stringency. The arguments for competitive bonus bidding are strong in most cases; however, they are not applicable to all situations. If the analysis made in this article is correct, bonus bidding is not applicable to situations where considerable research, or exploration in virgin territory, is expected to be necessary before a known mineral deposit will be economic, or the presence of mineral deposits will be proven.

In competitive research expenditure bidding, the principal bidding variable is the level of the firm's committed research expenditures,

* The research for this article was financed by a Ford Foundation International and Comparative Studies Grant to the University of California, Los Angeles.

† Assistant Professor of Economics, University of California, Los Angeles.

1. Mining Act of May 10, 1872, ch. 152, 17 Stat. 91.

2. Mineral Lands Leasing Act of February 25, 1920, ch. 85, 41 Stat. 437 (codified in scattered sections of 30 U.S.C.).

with the distribution of expenditures among the various possible problems to be researched, the timing of the expenditures, and the set of problems to which the firm intends to devote its research efforts being possible secondary bidding variables. The landowner should select competitive research expenditure bidding if he believes the present value of his remaining unleased lands will be sufficiently enhanced by the technical progress expected to result from the higher level of research expenditures to increase his wealth over what it would be if he adopted the best alternative leasing policy. In the case of exploration expenditure bidding, the landowner's objective is to get maximum expenditures on the exploration of his lands.

Since the federal government most likely would have to lease only a small percentage of its oil shale lands to obtain a relatively high level of research expenditures on shale oil technology, research expenditure bidding is probably applicable to the initial leases of government oil shale lands. Once technical progress has proceeded to the point where additional research expenditures are expected to be relatively less productive than they were at the start of the leasing program, it will become wealth maximizing for the government to switch to competitive bonus bidding for leasing the remainder of its oil shale lands. Note that research expenditure bidding is more practical for the initial leases of government oil shale lands than would be the case if the oil shale lands were owned by many small landowners.

In general, competitive bidding is the procedure for awarding mineral leases which maximizes the landowner's wealth since competition among the bidders insures that he will capture the economic rents inherent in his reserves. In the case of competitive research expenditure bidding, the economic rents inherent in the property are captured by the landowner in the form of higher research expenditures; whereas, with bonus bidding the economic rents inherent in the property are translated into cash payments to the landowner. Competitive bidding with respect to the royalty rate results in a misallocation of resources from the point of view of the landowner and society, since it results in premature abandonment of the mineral extraction process, but it too results in capture of all available economic rents by the landowner.

The theoretical discussion in this article is based on the assumption that the landowner and the firms bidding for the leases are wealth maximizers given their present, *ex ante,* expectations of the levels of the variables determining their wealth under the various alternatives open to them. Thus, what may appear to be the wealth maximizing strategy when the lease is offered, may *ex post* turn out

to be a poor strategy. This is a characteristic of situations where there is uncertainty with respect to the future level of one or more of the variables entering into the wealth of the landowner or the bidders for the leases. Where research leading to major technological breakthroughs or minerals exploration in virgin territory is concerned, uncertainties as to the *ex post* values of many key variables are relatively great. As presented here, the theory of competitive research expenditure bidding is based on the assumption that the relevant *ex ante* forecasts have been reduced to certainty-equivalents so that the discussion will be as uncluttered as possible with matters other than the role of research requirements in minerals leasing policy.[3]

This discussion also presumes that close substitute minerals exist so that the landowner's leasing policy does not influence the market price of the mineral. Although the government's oil shale reserves are definitely large enough to affect the market price of oil, this assumption is used because it facilitates discussion of the social efficiency of research expenditure bidding. When the landowner's holdings of the mineral are large enough to influence its market price, the wealth maximizing policy for the landowner will, from the social point of view, result in too few resources being used on his deposits at any given time. However, since the choice between competitive research expenditure bidding and bonus bidding is basically independent of the relative extent of the landowner's reserves, the monopoly issue is not discussed here.

COMPETITIVE BONUS BIDDING

The maximum bonus a firm will bid for a given mineral lease is the present value of the net cash flow from the lease, with the discount rate set at the minimum rate of return acceptable to the firm. Since the cash flow from the property depends upon production costs, and hence the state of technology with respect to extracting and beneficiating the mineral, the bonus bid for a lease where

3. The possibility of political criticism resulting from an *ex post* outcome unfavorable to the government can lead the government to adopt leasing policies which are utility maximizing for the party in power. Where uncertainty is particularly great, the utility maximizing policy is often to do nothing—not lease the lands. The way to overcome the political dangers inherent in leasing where the outcome is relatively uncertain is not through incorporating a renegotiation provision in the lease or the government's performing research aimed at reducing the uncertainties associated with leasing the land. The best solution appears to be through legislation, preferably with strong bipartisan support, specifying in considerable detail the leasing policies to be followed by the Department of the Interior. The proposed legislation "Oil Shale and Associated Minerals Leasing Act of 1968" (S.4190, 90th Cong., 2nd Sess.) authored by Senator Hansen of Wyoming is an example of this type of legislation.

significant research expenditures will be required before the mineral is economic depends upon the future levels of (a) the firm's own research expenditures, (b) the expenditures of other firms in the industry (including firms which produce capital goods for the industry), and (c) the landowner's research expenditures. That is,

$$(1) \quad F_t = F_t(\overline{R}_t; \overline{I}_t, \overline{L}_t, Q)$$

where F_t is cash flow at time t, $\overline{R}_t$, $\overline{I}_t$, and $\overline{L}_t$ are the cumulative expenditures on the firm's, the industry's, and the landowner's research, respectively, and Q represents all other factors which are being held constant.

If the landowner selects competitive bonus bidding as the means of allocating a lease to one of many competing potential lessees, the bonus bid, B, of each potential lessee would be

$$(2) \quad B = \int_0^n [F_t(R_t; I_t, L_t, Q) - R_t]e^{-rt}dt$$

where r is the minimum rate of return acceptable to the firm (the discount rate) and n is the life of the deposit. The values of each variable on the right hand side of (2) depend upon the firm's assessment of their future values. For this reason, the bonus bids of different firms may vary widely. If there are only a few bidders, so that competition is not effective, the firm may develop a bidding strategy and bid less than the maximum bid.

Equation (2) is a simplified representation of the factors which enter into determination of the maximum bonus the firm can bid for the lease and still earn its minimum acceptable rate of return. Many crucial variables were held constant in equation (2) so that the discussion here can concentrate on research expenditure levels. For example, the level of the bonus depends upon the scale of the extraction and beneficiation plant the lessee expects to construct, since capital and operating costs and the life of the deposit depend on the scale of the plant. For the purposes of this discussion, the reader can presume that the levels of all variables in Q which are controllable by the firm have been adjusted so that the bonus (economic rent) is maximized for each level and temporal distribution of research expenditures. This assumption permits avoiding some very complex mathematics that add nothing to the present discussion. In actual practice, however, all variables controlled by the firm are varied jointly with R_t to maximize the bonus.

Since it is assumed that effective competition prevails, the firm must adjust the level of R_t for all t so that the bonus is maximized

if the firm is not to jeopardize its prospects of obtaining the lease (this condition could be used to define "effective competition"). The result of this process of adjusting the levels of research expenditures in each year is the level of total research expenditures by the firm which would prevail under bonus bidding. Once the bonus is maximized by a given level and temporal distribution of research expenditures, the firm will not commit itself to additional expenditures on research, for to do so would reduce its rate of return on the lease below the minimum acceptable rate. If additional research expenditures by the firm would increase the wealth of the landowner, by increasing the value of his unleased lands, the landowner must either make the research expenditures himself or lease additional tracts and thereby increase the industry's expenditures on research.

COMPETITIVE RESEARCH EXPENDITURE BIDDING

Assume now the landowner specifies that the lease will be awarded to the firm agreeing to make the greatest total expenditures within the first y-years of the lease period on research into extracting and beneficiating the mineral, and that the landowner puts no constraints on the temporal distribution of the research expenditures or the specific technological problems to be studied. Under these bidding rules, the firm will increase its total research expenditures to the level where the present value of the lease, B in equation (2), equals zero. Research expenditures cannot be increased beyond this level, for otherwise the firm will earn less than its minimum rate of return. If competition is effective, the firm cannot commit itself to spend less than this amount on research or it would jeopardize its winning the lease.

Determination of the proper discount rate to use in computing the economic rents inherent in the landowner's tracts is a relatively complex issue that need not be discussed in detail here. The landowner in assessing the relative merits of competitive research expenditure bidding or bonus bidding should always use the relevant market discount rate.[4] The problem here is that the discount rate is not independent of the bidding variables or the particular set of lease terms specified by the landowner. For example, bonus bidding increases the risk exposure of the bidder relative to royalty or profit-share bidding, since in the latter cases the landowner directly absorbs a portion of the risk that the project will not be a commercial success. The appropriate discount rate for competitive re-

4. For a detailed discussion of the discount rate problem, *see* Hirshleifer, deHaven & Milliman, Water Supply 139-51 (1960).

search expenditure bidding would likely be lower than for bonus bidding, since the firm would be able to salvage more from an unsuccessful project if it performs the added research implied by research expenditure bidding. The lower discount rate applicable to research expenditure bidding increases the economic rents inherent in the tract; thus, it is to the advantage of the landowner whose objective is to maximize the value of his reserves.

MULTIPLE TRACT LEASING POLICY

Under competitive bonus bidding, the firm ceases adding to its total research expenditures when an additional dollar spent on research, in any time period, adds less than the present value of that dollar to the present value of the cash flow from the lease. On the surface, this appears to meet the standard marginal conditions for socially efficient expenditures on factors of production. However, this research expenditure pattern by no means need be socially efficient, because successful research generally produces significant external economies.

The landowner should include in the specifications of the lease the condition that the patents resulting from the research performed by the lessee are to be licensed to all other lessees, present and future, either royalty-free or with royalties to be determined by some specified formula. In either case, the firm will take the licensing provisions into consideration when it determines its maximum level of research expenditures. Since the firm will bid a higher level of research expenditures if it can receive royalties on its patents, the landowner will probably find it advantageous to permit the firm to charge a reasonable royalty. The royalty should not be set at a relatively high level, however, for otherwise the firm will place a relatively low value on the research performed by other firms subject to the same leasing provisions. Thus, the landowner must determine the trade-off point where a higher royalty will increase the firm's research productivity by the same amount that it will decrease the research productivity of all other firms in the industry.

If external economies from research obtain, the condition for socially efficient research expenditures is that an additional dollar on research so long as the present value of the marginal research dollar be spent equals the present value of the increase in the value of all deposits of the mineral. Under competitive bidding, with external economies from research, the firm will spend too little on research. Research expenditure bidding will also be socially inefficient because the firm will spend too little on research. Under research

expenditure bidding, the firm increases its total research expenditures so long as the marginal dollar does not result in the present value of the lease falling below zero, for otherwise the firm would earn less than its minimum acceptable rate of return. Since the firm can obtain none of the increase in economic rents from the deposits it does not own, the firm will necessarily spend less than the socially optimal amount on research.[5]

If many landowners own the deposits of the mineral, there appears to be no private way of obtaining a socially efficient level of research expenditures short of pooling all landowners' interests.[6] Each landowner will support research only to the point that the value of his deposits is maximized, leaving all economies external to his deposits unrealized. In this event, the government may, but not necessarily, provide the additional research expenditures necessary to yield the socially optimal level, financing the research by an appropriately neutral tax.

If one landowner owns all deposits of the mineral and the level of research expenditures implied by research expenditure bidding for one lease does not maximize the present value of all deposits of the mineral, the landowner is faced with three alternatives: (1) he may increase the size of the tract to be leased, (2) he may increase the number of tracts to be leased, or (3) he may perform a portion of the research himself. Alternative (1) is available so long as the present tract size is too small to support a plant exhausting all expected economies of scale in the production of the mineral, given the expected technology to result from the optimum level of research. Since the landowner, in the process of maximizing his wealth, should have set the size of the lease at the level exhausting the expected production economies of scale, increasing the number of tracts or landowner expenditures on research are the relevant alternatives here.

With research expenditure bidding, the amount the firm will spend on research depends on the economic rents inherent in the tract to be leased. Once the tract is large enough to exhaust the expected economies of scale, doubling the size of the tract will not double the economic rents inherent in the tract if diseconomies of scale are encountered in the production process. In this event, it pays

5. This would not be the case if the firm could patent its technology and enforce its rights to the patent at no cost. In this case, the firm could obtain a portion of the rents on the land, with the actual proportion obtained being subject to duopoly bargaining with the landowner.

6. This statement does not hold if patents are fully and freely enforceable, in which case the lessees would have incentives to do further research in hopes of capturing a portion of the land rents via patent royalties.

the landowner to offer two tracts for leasing if there are no economies of scale to single-firm, multi-plant operations and research is performed under conditions of constant returns to scale. If research would yield increasing returns to scale for the scale implied by two tracts of optimum size relative to the production process, the landowner would find it advantageous to offer the two tracts in one lease so long as any diseconomies of multi-plant operations do not offset the economies from a larger scale research effort. However, since constant returns to scale in research are probably obtained after a relatively low activity level, multi-tract leases should probably be subjected to the market test by offering single tract leases with no constraints on the number of leases a single firm can obtain.

If the number of optimum size tracts the landowner has available for leasing is relatively large, in principle it would be possible to obtain the socially optimal level of research expenditures by either competitive bonus bidding or competitive research expenditure bidding. However, research expenditure bidding is the wealth maximizing method since it permits obtaining the optimal level of research expenditures through leasing the minimum number of tracts of land. This results because research expenditures are maximized for each lease. Because the landowner receives no rents on the tracts he leases under research expenditure bidding, he wants to retain the maximum number of tracts for leasing after the technology for producing the mineral is developed and proven, for it is from these remaining leases that the landowner will receive the economic rents that directly increase his wealth.

If the landowner leases more than one tract of land, the firms bidding for the tracts must take not only their expenditures on research into consideration but also the expected levels of research of the other firms obtaining leases. It is for this reason that the variable $\overline{I}_t$ was introduced into equation (2). The more other firms are spending on research, given the controlled licensing provision in the leases, the greater the maximum bonus the firm will pay for any given level of its own research expenditures, because the research expenditures of the other firms increase the probability that significant technical progress will occur. Thus, when more than one tract is offered, the firm will bid a higher level of research expenditures than if only one tract were being offered. In terms of Fig. 1, the curve $B(\overline{R}_y)$ shifts upward with increases in $\overline{I}_y$, thus increasing the level of research expenditures for the firm at which B equals zero ($\overline{R}_y^e$). This provides an additional benefit for the landowner when competitive research expenditure bidding is used rather than bonus bidding. Not only does the landowner get more research ex-

Fig. 1. Research Expenditures under Bonus Bidding ($\overline{R}_y^b$) and Research Expenditure Bidding ($\overline{R}_y^e$).

penditures from leasing a given percentage of his land, but he also gets higher research expenditures from each tract since the firm knows that the other firms in the industry will spend more on research with research expenditure bidding.

LANDOWNER'S RESEARCH POLICY

The landowner's research expenditures increase the value of his deposits in much the same manner as expenditures on research by firms in the industry. So long as there are constant returns to scale in research, and the landowner can perform research as efficiently as the firms, the landowner's wealth will be increased as much by his performing the research as if it were performed by the lessees. It may be argued that given the above assumptions, the landowner would be better off if he performs the research himself, since he will have the research results and the land too, which he can put up for bonus bidding. This argument, however, is fallacious because the landowner in neither case "gives away" any of the economic rents inherent in the tract to the lessee. If the firms are better able to perform the research, the landowner should not engage in research, for to do so would reduce his wealth.

In the case where the landowner can perform the research as efficiently as the lessees, research expenditure bidding can be equivalent to a mixture of bonus bidding and landowner sponsored research. The competitive bidding process will insure that the firms bidding for the leases will make the remaining research expenditures necessary to obtain the efficient level of research expenditures, so long as the landowner makes research expenditures of an amount at least equal to the amount necessary to cover external economies from research. Thus, an efficient leasing policy can be devised where bonus bidding is used to allocate the leases. But note that this equivalence depends upon the existence of constant returns to scale in research and equal efficiency for the firms and the landowner, two conditions that may not frequently obtain in actual situations.

OPTIMAL LEASING STRATEGY

The landowner's wealth maximizing leasing strategy can now be indicated. The landowner divides his holdings into optimal sized

tracts from the point of view of producing the mineral. He then leases tracts, using competitive research expenditure bidding, until leasing another tract would add less to the present value of the expected economic rents from his remaining unleased lands than the reduction in the present value of the economic rents from the incremental tract at the lower level of research expenditures. Where research expenditures are expected to yield only evolutionary changes in presently commercial technologies, research expenditure bidding probably would not increase the landowner's wealth since the optimum amount of research expenditures may be less than the economic rents on an optimal sized lease from the standpoint of production. In this case, the landowner's wealth maximizing strategy is to specify the level of research expenditures the lessee must make to retain the lease and to capture the remaining economic rents via bonus bidding.[7]

Once the initial tracts of land have been leased, as time passes the landowner must periodically decide whether (1) waiting for more research results from the present leases, (2) offering additional research leases or engaging in more research of his own, or (3) offering additional leases on the basis of competitive bonus bidding will maximize his wealth. If the landowner's initial leases do not produce the expected reductions in cost, the landowner may have to revise his leasing plans to fit the then existing situation. In doing so, he must again determine if additional research expenditures will add more to the present value of his remaining unleased lands than the present value of the land to be leased given the current technology.

In actual practice, the number of tracts to lease and the proper leasing procedure would be difficult to determine since so many of the key variables have to be estimated on the basis of little more than an educated guess. The key point, however, is that the landowner is less likely to lease too few tracts and obtain too low a level of research expenditures if he uses research expenditure bidding than if he uses bonus bidding; and this conclusion probably holds whether the landowner controls all deposits of the mineral or, say, 80 per cent of the reserves.

The question now arises as to whether the leasing policy which maximizes the landowner's wealth via research expenditure bidding is also the socially optimal policy. A socially efficent allocation of resources obtains when changes in the quantity of any factor devoted

7. This bidding procedure is frequently used for petroleum and mining concessions in foreign countries. The strategy could well be optimal for many cases since there often is considerable geological evidence that the mineral may be present.

to a particular activity will reduce its market value, in this case the present value of the economic rents from the mineral deposits. Assume that the landowner cannot influence the price of the mineral by changing his leasing policy because of the existence of close substitutes. Spending another dollar more or less on research will not increase the present value of the mineral deposits, so research funds are being allocated efficiently. Since the maximum total research expenditure bid of each firm is computed jointly with the capital and operating cost levels of the technology that the firm expects will obtain after the research is completed, additions or deletions of units of these factors will not increase the value of the mineral deposits. Thus, competitive research expenditure bidding can yield a socially efficient allocation of resources if sufficient tracts are leased to exhaust the external economies from research.

Competitive bonus bidding on the other hand is socially inefficient as it is normally practiced when applied to situations where considerable research expenditures are required to make the mineral economic. The bonus payments drain capital away from research and fail to exploit fully the external economies generated by research.

CONCLUSIONS

The program of work provisions of the British North Sea oil and gas leases are similar to research expenditure bidding.[8] One of the factors used in awarding a North Sea lease to competing companies was the exploratory program to which the company was willing to commit itself. The result was a sort of going market price for leases in terms of exploratory expenditures. The analysis of this article indicates that the program of work aspects of the British policy were in the proper direction towards establishing the optimal level of exploration in the British North Sea. Note too that in this case where the tracts were relatively small and concentrated in one geological province, there are likely to be significant external economies from the drilling of exploratory wells, a condition which favors the use of research expenditure bidding. In this case, the British government planned to capture the remaining economic rents via a modest royalty and income taxes, rather than the combination of taxes and lease bonuses which appear to be favored for the U.S. oil shale lands.

The research lease policy proposed by the Department of the

8. For a discussion of the British policies *see* Dam, *Oil and Gas Licensing and the North Sea,* 8 J. Law & Econ. 51-76 (1965). Mr. Dam's assessment of the social efficiency of program of work bidding does not agree with that of this paper.

Interior in January 1967 for leasing several tracts of the government's oil shale lands was not a research expenditures bidding policy.[9] Interior proposed that the government negotiate with private companies for specific research programs, the successful completion of which would earn the company a production lease. This approach does not have the advantage of competitive bidding of insuring that the economic rents inherent in the tract are absorbed into the research expenditures. The revised procedures, issued in May 1968, shifted to competitive bonus bidding on a limited number of leases and provided for research leases with no guarantee of a production lease. Neither of the Department's programs aims at obtaining large private research expenditures on shale oil technology by utilizing the economic rents inherent in the tracts to support research. If anything, the bonus bidding approach favored by the Department serves to depress research.

The foregoing discussion of the economics of competitive research expenditure bidding has proceeded on the basis of a rather heroic set of simplifying assumptions to keep the analysis from becoming unduly complicated with factors which tend to distract from the crucial role of research expenditures in the leasing decisions of the landowner. A practical policy based on research expenditure bidding for the government's oil shale lands must necessarily grapple with the whole problem in its full range of complexity. Although the practical problems of working out an efficient research expenditure bidding policy cannot be minimized, the same problems are basically encountered in formulating an efficient competitive bonus bidding policy, and the principal finding of this article that research expenditure bidding is a socially optimal policy still holds. The case for competitive bonus bidding on oil shale leases, given the present lack of an obviously economic technology for producing oil shale, appears to be on weak theoretical grounds, although once the technology for producing shale oil has been proven to be commercial, competitive bonus bidding is the optimal social policy.

9. For a discussion of the 1967 and 1968 policies *see* U.S. Dep't of the Interior, Prospects for Oil Shale Development (1968).