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ORAL AND SEALED BIDDING, EFFICIENCY VERSUS EQUITY†

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This article will assess the equity and efficiency implications of oral versus competitive bidding for governmental sales and purchases, explore patterns of bidder behavior and their bidding procedures, and propose a new procedure for competitive sales that combines desirable features of both. The discussion will concentrate on sales of timber from the National Forests both because the problem has been intensively discussed in this context, and because both methods have been used for timber sales. The discussion will be later extended to cover sales of other natural resources, and the even more common cases of government purchases of goods and services.

In sealed bidding each bidder is allowed to submit one bid which he seals in an envelope prior to the appointed time for opening bids. At that time the bids are opened, and the timber is sold to the firm that offered the highest amount. This procedure is commonly used for sales of Eastern timber, for most sales of government-owned mineral resources, and for government procurements.

Oral bidding is an auction. Those interested in a particular lot of timber assemble together at the time of the sale. A potential buyer states an offer for the timber. If another is willing to pay more, he makes a higher offer which in turn may be topped. When an offer is made that no one is willing to exceed, the sale is made at this price to the person who made this last offer.

†Work began on the efficiency effects of different bidding systems when the author was with Abt Associates as Principal Investigator for a study of Fuel Minerals on the Public Lands commissioned by the Public Land Law Review Commission. The author is heavily indebted to Professor Mead of the University of California at Santa Barbara who did much of the pioneering work on the economics of the timber industry and the significance of different bidding systems. Professor Mead's work has appeared in one book, Mead, *Competition and Oligopsony in the Douglas Fir Lumber Industry* 199, (1966), and in a journal article, Mead, *Natural Resource Disposal Policy-Oral Auction Versus Sealed Bids*, *Natural Resource J.* 194-224 (1967). (These are referred to here as the book and the article respectively.) The reader is referred to these excellent discussions for additional information on the economics of the timber industry, or a description of Forest Service procedures that goes beyond the brief outline included here.

There is also a detailed description of current timber sale procedures in the Study of Public Land Timber Policy prepared for the Public Land Law Review Commission by George Banzhof & Company (April 1969).

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REQUIREMENTS FOR EFFICIENCY

Before considering the effects of bidding systems on efficiency it is necessary to discuss the necessary conditions for efficiency. The primary requirement is that timber harvesting and processing be done by the firm with the lowest marginal costs. Which firm has the lowest marginal costs for a particular stand of timber will depend on the distance between the firm's sawmills and the stand of timber, on the size and species of the timber, and on other factors that will vary with the lot being sold. If there is excess capacity so that the timber can be harvested without having to increase saw mill capacity, the marginal costs will be short-run marginal costs excluding any capital charges on fixed investment. If the firm already has access to sufficient timber to keep its plant operating at capacity, and any additional purchases of timber would require an expansion of the plant, the marginal costs must include a return on this capital.

The maximum amount that a firm is willing to pay for standing timber is the difference between the price it can sell lumber for and its marginal cost for converting timber into lumber. If it offers more it will experience a loss. (Of course, if it can it will offer less.)

The market for lumber is close to being perfectly competitive with a large number of buyers competing nationwide.¹ Since all firms can sell their lumber for the same price, it follows that the firm with the lowest cost will also be the firm with the highest ability to pay for timber. Thus any sales method that directs the timber to the firm with the highest ability to pay will insure that production is performed by the firm with the lowest cost. Notice that efficiency requires merely that the low cost firm win the bidding, not that it pay any particular price.

ORAL BIDDING

By the above standards, oral bidding is an efficient method for selling timber. The firm with the highest ability and willingness to pay will normally win the bidding. If another firm threatens to take the timber with a price lower than the maximum the low cost firm is willing to pay, this firm will raise its bid. If the price is above a firm's willingness to pay, it will not raise the bid. This will indicate that it is not the firm with the highest willingness to pay, and not the firm with the lowest cost.

1. W. Mead, *Competition and Oligopsony in the Douglas Fir Industry* (1966).

SEALED BIDDING

With sealed bidding, there is an appreciable risk that the low cost firm will not be the winner. A higher cost firm will win whenever the low cost firm underestimates the amount other firms will bid. Given the difficulty of anticipating bids, such errors can be expected to be frequent.

To indicate why such errors are to be expected let us examine the behavior of a profit-maximizing firm in sealed bidding. If it knew the amounts other firms would be bidding, its strategy would be to bid just slightly more.² If this amount exceeded its maximum willingness to pay, no bid would be made.

In practice, there is not such knowledge about bidding plans of competitors. All the bidder has are estimates of the probability that he will win by bidding certain amounts in any particular sales.³ The bidder's goal will normally be to maximize his expected profit. This is the product of his probability of winning the bidding and the profit if he does win the bidding. The profit is the sales price of the lumber produced minus the costs of production and minus the amount paid for the timber.

Let x be the bid price
 $p(x)$ the probability of winning with a bid at that price
 C the cost of the bidding firm
 L the price of lumber
 M the maximum willingness to pay of the bidder
 P the profit

As

$$M = L - C$$

$$P = L - C - x$$

$$= M - x \text{ if the bid submitted is the high bid}$$

The expected value for profit is $P \times p(x)$ or

$$(M - x) p(x)$$

The bidding firm will select x so as to maximize the expected profit which requires that:

$$\frac{\partial}{\partial x} [p(x) (M - x)] = \frac{\partial p(x)}{\partial x} (M - x) - p(x) = 0$$

$$\frac{\partial p(x)}{\partial x} = \frac{p(x)}{M - x}$$

2. Of course the bidder may be aware that the amounts that other firms will bid in future sales will depend on the amounts that he bids in this sale. This complexity will be disregarded in this introductory discussion.

3. In practice such probability estimates may not be made explicit. Indeed, the bidder may deny that he has any such estimates.

In general, the probability of winning the bidding will be less than one. Thus, with sealed bidding, there will be cases in which the less efficient firm wins the bidding and receives the timber. The primary reason for this is the difficulty of predicting the bids of opponents.

THE ARGUMENT IN GRAPHIC FORM

In Diagram 1 the curve GAF indicates the firm's estimated probability of winning as a function of the amount bid. The higher it bids the better its chance of winning. The firm's maximum willingness to pay is M. The profit⁴ if it wins with a bid of X is $M-X$. With a bid of X, the probability of winning is estimated to be A. The expected profit is then $A(M-X)$, which is the area of the rectangle ABMX. The profit maximizing firm will select its bid so as to maximize the expected profit, or the area ABMX.

One should notice that the amount of the bid X will always be below M if the firm is bidding. The fact that it is bidding indicates that its expected profit is positive. For a positive expected profit the area ABMX is positive which means its base must have a finite length, i.e., the firm will never bid its maximum willingness to pay, unless the goal is to eliminate a competitor.

Since the firm never bids its maximum willingness to pay, there may be cases when it is outbid by a firm with a lower willingness to pay. When this happens, the timber is processed by a high-cost firm.

If the curve GAF intercepts the line KN (where p is unity) at a point E which is to the left of N, the bidding firm can win all bids by always bidding slightly more than E. Whether this strategy would be optimal for the bidding firms depends on whether the potential profits of $(N-E)$ exceed area ABMX which is the maximum profits obtainable without winning all bids. Given the high degree of uncertainty about the costs and bidding strategy of opponents, it is highly unlikely that the probability-bid curve will intercept the $p = 1$ axis to the left of N.

THE CASE OF A SMALL NUMBER OF BIDDERS

When there is only one bidder sealed bidding is likely to produce higher returns than oral bidding. The reason is that unless there is someone to raise a low opening bid, the timber will be sold at the appraised price. With sealed bidding a bidder may fear that someone will offer more than the minimum and will himself bid above the minimum.

The basic mechanism can be illustrated by considering the case of two identical firms. Assume that opponents' bids are expected to be

4. Before meeting fixed costs.

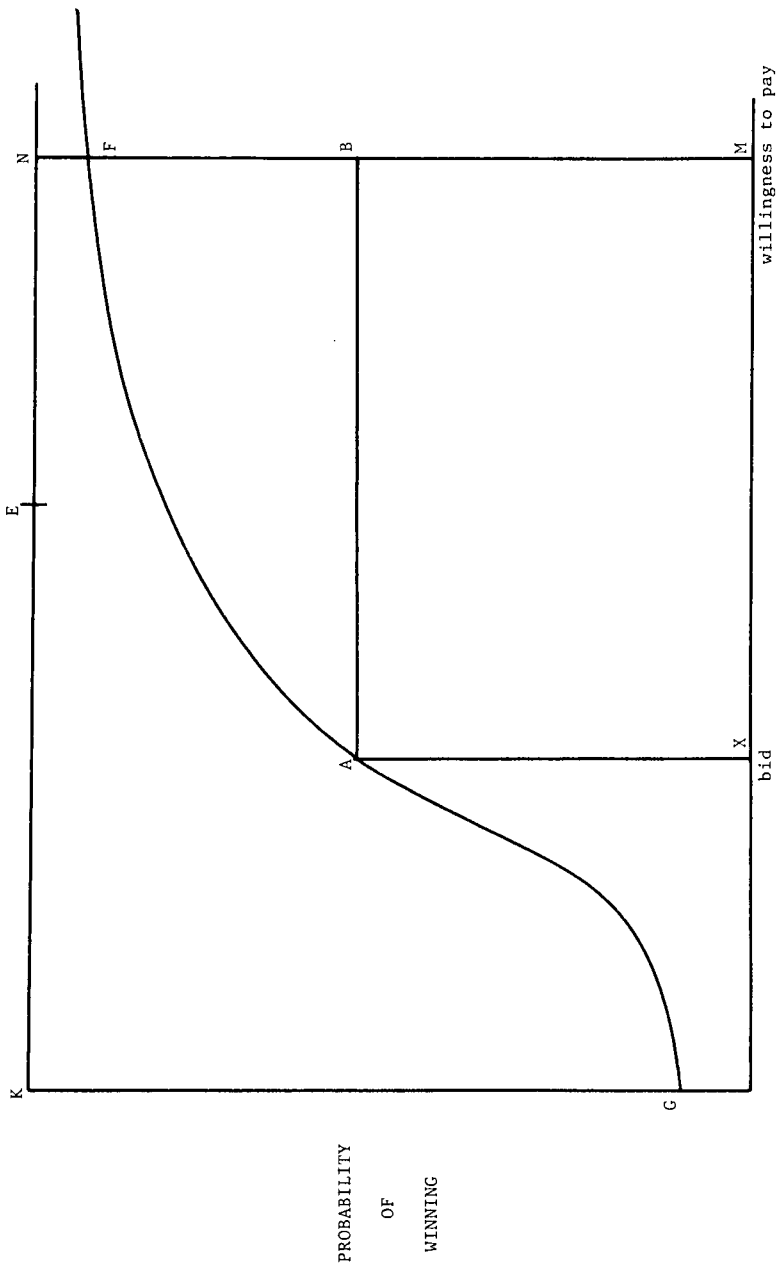


DIAGRAM 1
SELECTION OF BID

normally distributed. Since both firms are acting from similar information, it is assumed that the expected distributions of bids for opponents will be equal (by symmetry).

Let x be the amount bid by a firm, and M its maximum bid.

p is the probability of winning with a bid of x .

Thus, the expected profit is $p(x)(M-x)$, which is maximized for

$$dp/dx = p(x) / (M-x)$$

For the case of two identical firms, the only probability of each winning that is consistent with the assumption that they are identical is .5 ($p = .5$). The differential of the cumulative probability function $p(x)$ is a normal function. If s is the standard deviation of the distribution, dp/dx where $p = .5$ is $.3989/s$ from a table of values of the normal function. Therefore,

$$dp/dx = p(x) / (M-x) \text{ becomes}$$

$$.3989/s = .5(M-x) \text{ and}$$

$$M-x = .5s/.3989 = 1.258s$$

In other words, the two firms will eventually settle on a stable bidding pattern with the distribution of each firm's bids centered $1\frac{1}{4}$ standard deviations below its maximum willingness to pay.⁵

With oral bidding, the two firms would bid each other up until they were both paying M . Notice that in the case of two identical firms sealed bidding produces lower revenues to the seller than oral bidding, and that the difference increases with the uncertainty in estimating the bids of the competition. The latter effect arises because greater uncertainty reduces the perceived elasticity of supply with regard to the amount bid and makes the profit maximizing offer lower.

In the more general case of two firms with different costs and hence different willingness to pay the stable pattern of bidding is more difficult to calculate. The firm with the highest willingness to pay will win the larger amount of timber and will have the higher expected value for its bids. The larger the advantage of the efficient firm the higher its bid and the higher the fraction of the available timber it will be able to purchase.

BIDDER'S APATHY

Oral bidding is subject to the problem of bidder's apathy. Bidders become apathetic and cease to bid if they believe that they don't stand a chance of winning. The most common cause for this situation

5. The gap between M and the revenue derived from the sale is less than $1.258s$ because the sale is made at the higher of the two bids received.

is that another firm has a clear-cut competitive advantage, perhaps a mill located close to the timber being sold. When firms don't bother to bid because of apathy the nearby firm can buy the timber for less than the willingness to pay of the potential second highest bidder. When all firms except the expected winner are apathetic the timber will be sold for the appraised price, greatly reducing the government's revenue.

Theory suggests that this outcome of a single firm being able to purchase timber for the appraised price should be common. All that is necessary is (1) for one firm to have a cost advantage which gives it a consistent advantage in willingness to pay,⁶ and (2) for the existence of this advantage to be well known, and (3) for there to be a finite cost to bidding. These conditions would seem to be commonly met. Mills normally differ in location and efficiency. These differences are often well known. And there are costs associated with bidding such as cruising timber⁷ and having a man present at the sale. Indeed, it would not be surprising if bidder apathy eliminated competition at most sales.

The factor maintaining competition is uncertainty as to how high another firm is likely to bid. Although some advantages such as location are apparent, others such as efficiency of labor, access to other sources of timber, may be unknown. These may be less apparent but clearly able to outweigh an advantage in the visible factors. If sales from a particular area are not too common, there may not have been time enough for the firms to learn that one of their number will always win. Similarly, where there are frequent small sales firms may learn that it is futile for them to bid for timber in certain areas.

The low cost firm may act to encourage a feeling of futility in competing firms by making it a rule not to be outbid on certain types of timber land. This is most likely to be attempted when location or some other cost advantage results in the firm winning most of the sales in the selected area. The cost of raising the percentage won to 100% will be small and the gains large if other firms can be induced to stop bidding against it.⁸ The chances of success may be enhanced by informally spreading word that the firm expects to win all timber within a certain area and that it is a waste of time to bid against it.⁹ This can become collusion when combined with an offer not to bid against firms that don't bid against it.

6. Which implies having adequate capacity to process the entire timber supply.

7. The cruising of timber is the process of estimating the volume and value of timber on a tract. The cost of doing this is normally significant.

8. And bid on timber in other areas where the competing firm does not have an overwhelming advantage.

9. Mead, *supra* note 1, at 154. Mead reports several cases of strategies of this type.

It is difficult to know how important bidder apathy is. A situation where each firm finds very little competition for timber near its mill may be due either to widespread bidder apathy or to an agreement among the firms not to compete.

Mead¹⁰ has found that only 67.9% of Forest Service timber sales via oral auctions were made at prices significantly above the appraised value. Judging from the fact that only 1% of the volume of timber in the Douglas Fir Region drew no bids, there were probably at least two firms in most of the non-competitive sales which could have paid the appraised price. Mead apparently attributes this lack of competitive behavior to collusion, although the concept of bidder apathy developed above provides an alternative explanation.

Indeed, Mead¹¹ himself developed a similar concept which he called bidder futility, although he did not apply it to this problem. The principal difference between the above argument and that of Mead is that he regards bidder futility as being felt only by small firms when faced with the market power of large firms, and uses it to explain his observation that large firms consistently acquire timber for lower prices than small firms. However, as shown above, bidder apathy can arise whenever any firm perceives that it cannot outbid another firm on certain timber. The firm benefitting from bidder apathy need not be a large firm; a large firm may decide it is not worth bidding against a smaller firm which is exceptionally well located with regard to the timber sought.

Whether bidder apathy is part of the explanation for the lower prices paid by large firms depends on whether large firms are more likely to have cost advantages apparent to potentially competing firms. There are several reasons for believing that this may indeed happen:

1. Gyppo loggers are small firms without fixed mills who often log timber for others, but sometimes bid on their own account. Lacking a fixed mill site they are unlikely to benefit from bidder apathy.

2. Large mills usually require a large working area. The potential competition from such mills may discourage other firms from establishing competing mills within this working radius. This will give the large mill a stronger locational advantage on timber close to it than small mills have on timber close to them.

In other words, if a mill can compete for timber 50 miles away, its willingness to pay for timber one mile away will be higher by the cost of 49 miles of haulage. This advantage in willingness to pay

10. Mead, *supra* note 1, at 213. The only mechanism producing non-competitive sales in the absence of collusion which is discussed is appraisal mistakes.

11. Mead, *supra* note 1. See ch. 13.

combined with the longer hauls for competitors may discourage them from competing for timber near the large mills.

IMPLICIT COLLUSION

Collusion may be either explicit or implicit. With explicit collusion the colluding firms decide before the bidding who among them will win and plan their bidding accordingly. With implicit collusion the firms do not meet but communicate information about their intentions through the bidding process itself. Such implicit collusion can even arise accidentally with sealed bidding.

To show this consider the case of two firms, one high cost and one low cost. Initially both firms bid on all timber. At first the inefficient firm consistently bids the maximum amount it can, and the efficient firm takes the timber by bidding just a little bit more. Eventually the inefficient firm begins to suffer discouragement and drops out of the bidding. The efficient firm will soon notice this and begin bidding only slightly above zero.^{1 2}

If the inefficient firm now responds by bidding occasionally the efficient firm may continue to bid low, allowing the other firm to win an occasional bid. As long as the inefficient firm doesn't get too ambitious the two firms can continue to share the timber with both firms paying virtually nothing.

The profit the efficient firm can earn by consistently bidding slightly more than the inefficient firm sets an upper limit to the amount of business the inefficient firm will be allowed to capture.

Let

M be the maximum willingness to pay of the efficient firm

m be the willingness to pay of the inefficient firm

p be the probability of the efficient firm winning

e be the infinitesimal amount by which the winning bid exceeds the second highest bid

The efficient firm by consistently bidding $m + e$ earns a profit of $(M - m - e)$.

With a strategy of bidding zero^{1 3} the efficient firm will earn average unit profits of pM where p is its probability of winning. This strategy will prove the profitable strategy only if $pM > M - m$. Thus, the condition for cooperation of the efficient firm is that $p > \frac{M - m}{M}$. The

12. The discussion here assumes that there is no legal required minimum bid such as an appraised value. In the case where there is the bids mentioned should be interpreted as being the amounts bid in excess of this legal minimum. For instance, a zero bid then corresponds to a bid at the appraised price.

13. In practice it would bid a small amount over 0 in order to have the highest bid, but this detail is not worth elaborating on here.

maximum fraction of the timber the inefficient firm can capture is then m/M i.e. $1 - \frac{(M-m)}{M}$, giving it profits of m^2/M . This is the best

the second firm can do without inducing the efficient firm to adopt a strategy of winning all bids with a bid of $M + e$. For the inefficient firm to realize profits of this magnitude it is necessary for the efficient firm to acquiesce in all of the gains of the implicit collusion going to the inefficient firm.

However, it is likely that the efficient firm would realize that its opponent's bidding strategy depended on the bidding strategy it adopted. By refusing to bid below m the efficient firm could apply pressure on the inefficient firm to accept less than m/M of the timber. Such a concession is necessary if the low cost firm is to have any incentive for reducing its bidding below m . It is impossible to say exactly what the outcome of implicit collusion involving the two firms will be. The typical bid is likely to be zero¹⁴ (or the legal minimum) because any higher bids do not maximize the joint profits of the two firms. How these joint profits are divided is indeterminate with the only constraint being that the higher cost firm cannot win more than m/M of the bids.

EFFECTS OF IMPLICIT COLLUSION

The effect of implicit collusion on the Federal government is to reduce its revenues from all timber sales by M . However, not all of this reduction in Federal revenue accrues to the timber purchasers. The efficient producer benefits to the extent of M on its purchases of timber, but the inefficient producer benefits only to the extent of m on the timber it purchases (due to its higher costs). On timber purchased by this firm there is an increase of $M-m$ in the cost of timber processing.

This higher cost of processing represents the efficiency loss from the implicit collusion. It is proportional to the fraction of the timber that is purchased by the less efficient firm. In the case where the inefficient firm captures the maximum amount of timber its increase in profits from collusion is $m(m/M)$ per unit and the increase in profits for the efficient firm is $M(M-m)$. Thus the total increase in profits is $\frac{m^2 + M^2 - mM}{M}$ per unit. Yet the decrease in government revenue is M . If the decrease in government revenue and the increase in private profits are both weighted equally, there is a net loss to

14. Or an insignificant amount about zero for the high-cost firm.

society equal to the difference between these two sums or $m \frac{(M-m)}{M}$.

This is also the product of the efficiency loss per unit processed by the less efficient firm $(M-m)$ and the fraction of the harvest it processes, m/M . The fraction of the loss of revenue to the government that accrues to the timber purchasers is $\frac{m^2 + M^2 - mM}{M^2}$.

This function passes through a maximum when the $m = 1/2M$, and the benefits to timber purchasers are only $3/4$ of the revenue loss to the government. The other $1/4$ represents a net loss to society. Thus, *at least* a quarter of the financial loss to the government is also a net loss to society.

IMPLICIT COLLUSION WITH MORE THAN TWO FIRMS

Implicit collusion can occur with three or more firms. Let us consider briefly the case of three. Let

M be the maximum willingness to pay of any of the three firms

m_2 be the second highest willingness to pay

m_3 be the lowest willingness to pay.

With successful collusion the level of bidding will approach the joint profit maximizing level of zero (or the appraised price). By the above argument, to keep the low cost firm from being able to improve its position by consistently bidding m_2 it is necessary that the other firms limit themselves to winning less than m_2/M of the timber. This is the same condition as in the two firm case. In addition, if the second most efficient firm is to be prevented from taking all of the timber of the two high cost firms by consistently bidding m_3 , it is necessary that the least efficient firm take no more than m_3/m_2 of the two high cost firms' share of the timber. Beyond these conditions for insuring that all three firms benefit from the implicit collusion, it is impossible to predict how the timber will be divided. However, it is considerably more difficult for three firms to establish and maintain implicit collusion than for two firms. Any disagreement can result in the breakdown of the agreement.

EXPLICIT COLLUSION

A primary purpose of the discussion of implicit collusion was to show that low bids, even zero bids, could result without firms meeting together and agreeing on joint bidding. Of course, such agreements may also be reached directly, giving explicit collusion. Unfortunately, explicit collusion is actually easier with competitive bidding than it is in most situations.

Normally, one of the difficult problems in maintaining collusive agreements is discovering violations. Prices may be shaded by offering rebates, absorbing freight, raising quality, or making errors in the customer's favor, as well as by direct price cuts. Because such chiseling is to the benefit of the customer, he has an incentive to keep it secret. To detect violations of the agreement it is often necessary to have an elaborate system of reporting and auditing. However, it is difficult to operate such a system without revealing the agreement to the antitrust authorities. This makes it difficult to enforce collusive agreements.

However, this problem is not so difficult in a bidding situation. Because the firms are all bidding only on price, evasion cannot occur through secret concessions, rebates, etc. Since bids are made public during the course of an auction, and usually by law after the opening of sealed bids, there is no difficulty in discovering and punishing violators.

As indicated above, with oral bidding it is relatively simple to maintain a cartel agreement once one has been reached. Unfortunately, such an agreement may be relatively easy to reach too. In many cases different purchasers of timber have natural supply areas. All that may be needed for an agreement is, "If you don't bid on timber in my area, I won't bid in your area."

CHOICE OF BIDDING SYSTEM AND COLLUSION

As has been pointed out by Mead,¹⁵ collusion is more difficult when bidding is of the sealed type rather than oral. There are several reasons for this:

1. With sealed bidding there is a risk that a bidder not a party to the collusive agreement will take advantage of the low bids to win the timber, making the parties to the agreement worse off. For instance, if two firms agree that one of them will bid \$10 per thousand board feet for timber which could justify bids of \$30 while the other submits an inferior bid, there is a risk that a third firm may be found to have bid \$15 when the bids are opened. With oral bidding, the two colluding firms may raise their bids if unexpected competition appears.

2. With sealed bidding the breaking of an agreement by one of the participants will not be known until the bids are opened. The primary deterrent to such behavior is having to pay more in the future for timber due to having caused a breakdown of the agreement. However, if a sale of timber is large enough, a firm may make more

15. W. Mead, *Natural Resource Disposal Policy-Oral Auction Versus Sealed Bids*, 7 *Natural Resources J.* 194, 213 (1967).

on this single sale than it would lose from a breakdown of the agreement.¹⁶ This is especially likely if a single sale will provide enough timber for several years operation.¹⁷

With oral bidding, any violation of the agreement is immediately apparent, and the other parties to the agreement can raise their bids to prevent the offender from getting the timber, or at least to compel him to pay a competitive price for it. Thus with oral bidding there is no incentive to break an agreement.

3. With oral bidding it is easy to bid up any particular firm to punish it for breaking an agreement. All that is necessary is to raise the bidding whenever this firm appears. An aggressive policy can deprive the victim of timber, although this may be at the price of the attacking firms paying high prices for some timber. A less aggressive policy may limit itself to forcing the offender to pay competitive or more than competitive prices. If the attacking firm withdraws from the bidding before the attacked firm reaches its maximum limit, substantial penalties can be imposed at low cost to the attacking firm. Given the ease with which a firm can be bid up, it will be a brave firm indeed which will do anything to antagonize another firm in the industry. This power can be used not only to penalize those violating agreements, but to force uncooperative firms to participate.¹⁸

With oral bidding it is possible to make the specific threat of hurting a firm if they ignore the agreement. But with sealed bidding, the strongest threat is, "If you ignore the agreement, it will hurt all of us." The worst that can happen to the violator with sealed bidding is for there to be a return to competitive pricing. Since the damage to the offender is only a fraction of the total damage, there will be a strong incentive not to invoke the sanction of a return to competitive bidding. That "this will hurt us more than it will hurt you" will be known to any potential violator. The high cost of enforcing a collusive agreement cannot fail to reduce the creditability of threats against violators.

Suppose the non-joiners are small firms that purchase only a small fraction of the available timber and hence would bear only a small

16. The phenomenon has been observed in the cement industry. Henry J. Kaiser won the contract to supply the concrete for building Shasta Dam in California by bidding below the basing point formula being used by the other producers. Because this contract for 5,800,000 barrels would consume several years output of his intended 2,500,000 barrel plant, he was willing to risk retaliation or a spate of price competition. See S. Loescher, *Imperfect Collusion in the Cement Industry* 187 (1959).

17. Incidentally, because of the temptation provided by a large sale, such sales may actually be less subject to collusive agreements than frequent smaller sales.

18. Of course, a firm might be deliberately bid up to penalize it for other offenses such as raising wages, cutting lumber prices, or violating an agreement on sealed bidding.

part of the increased cost of a return to competitive bidding. In this case there will be a strong temptation for the other firms to allow such small firms to remain outside the agreement on the argument that profits are greater with an imperfectly observed agreement than with no agreement at all. Over time more and more small firms will come to operate under the umbrella provided by the agreement. Eventually, the agreement is brought down. In contrast, with oral bidding, selective retaliation against violators prevents such erosion of an agreement.¹⁹

OTHER FORMS OF BIDDING

So far the discussion has concentrated merely on the advantages of oral versus competitive bidding. It was shown that oral bidding would normally lead to the most efficient processing of the resources, and the greatest gross national product. Either might bring the greatest revenue to the government depending on the number of bidders and the difference in their willingness to pay. However, collusive bidding is much more likely with oral bidding than with sealed bidding.

Fortunately, there are other methods of sale that can be adopted besides conventional oral and sealed bidding. Some of these have advantages which may make them preferable to either.

THE DUTCH AUCTION

What has been here referred to as merely oral bidding is also known as an "English auction." Bidding starts low and progresses upwards. With the Dutch auction the auctioneer starts with a high price which is gradually lowered until a taker is found. The significant difference with the English system is that there can be no responding to opponent's bids. Thus, in its effects this sales procedure is very similar to conventional sealed bidding. Like sealed bidding, the less efficient firm will often fail to win because of underestimating the competition. Although the bidding is verbal, there is no way for members of a bidding cartel to adjust their bidding strategy to the bids of outsiders. Thus the risk of bids being collusive with a Dutch auction is very similar to the risk with sealed bidding. The only difference is that it may be possible to gain some information about the possibility of bidding by non-members of the agreement from who attends the sale. The appearance of a known representative of a non-member of the agreement may lead to abandonment of the

19. The process described above for sealed bidding is similar to that which eventually destroys many price fixing cartels. The difficulty of retaliating against a small firm leads to the toleration of some price cutting which increases until the cartel is destroyed.

agreed low bid for a higher bid. Likewise, if there is no one present but participants in the bidding agreement it is safe to bid low. Usually, however, outsiders will be represented by stand-ins and there will be a number of unknown people present at any auction. When this happens, little information can be obtained from who is physically present at an auction and the ease of collusion comes to resemble closely that in conventional sealed bidding.

While a Dutch auction does not allow response to the specific bids of competitors, it does allow response to which parcels are being won. A small firm which desires to bid on only part of the lots being sold is at a disadvantage in a sealed bid sale. It dare not bid on all of the parcels offered for fear that it will win all or most of them and either be physically unable to exploit them or financially unable to pay for them. Yet by bad luck it may fail to win any of the desired resources. In an auction sale, whether "English" or "Dutch" the bidding strategy for one parcel does not have to be selected until it knows whether it has won other sales. This makes it easier to buy the desired quantity of a resource. For mineral resources this advantage involves the risk that a firm might be deterred from bidding high on early parcels for fear of revealing a high valuation of deposits extending over several parcels.

In general a Dutch auction is equivalent to sealed bidding where the bids on unsold parcels can be changed upon seeing the results of sales of earlier parcels.

A SALES STRATEGY TO PROMOTE EFFICIENCY

It was shown that oral bidding (where the most efficient firm can always outbid its competitors) will cause natural resource exploitation to be done by the low cost firms. This advantage in efficiency is partially offset by the ease with which collusion can arise in an oral bidding situation. This naturally leads to a search for a sales system which retains the efficiency advantage of oral bidding but is less prone to collusion.

There is such a system. Each firm submits prior to the sale a statement of the maximum amount it is willing to pay (hereafter referred to as the bid). At an appointed time the bids are opened and the tract is sold to the firm with the highest bid. However, the price is the amount specified in the second highest bid. This system awards the timber to the firm with the highest willingness to pay. This will normally be the firm able to process the resource at the lowest cost. The price paid is the maximum willingness to pay of the other firms. Because the price paid for the timber is not the "bid" of the winner but that of the runner up, there is not the incentive to conceal one's

willingness to pay that there is in a system where the amount paid is the amount bid.

In oral bidding each firm sends a representative to the auction with instructions to bid up to a certain amount. The firm that has given its representative the highest maximum amount will win the bidding. However, to win, its representative will have to bid only an infinitesimal amount above the upper limit of the representative with the second highest upper limit. Thus, the sale is made to the firm with the highest upper limit but at essentially the maximum willingness to pay of the second highest bidder.

In the proposed system, the firm instead of giving its upper limit to a representative at the auction, sends the upper limit to the government. The government simulates an auction, awarding the sale to the firm with the highest upper limit, and setting the price at the upper limit of the second highest firm. This is done without the expense of actually holding an auction. Thus, the proposed bidding system will be referred to as simulated oral bidding. Let us see now what advantages it may offer besides economy.

SIMULATED ORAL BIDDING'S VULNERABILITY TO COLLUSION

With simulated oral bidding, collusion is less likely because bids are submitted before it is known who the other firms are, or how much they are bidding. There is no way to retaliate against specific firms, because there is no way to know who will ultimately be the high bidder. Thus, a violator of an agreement or a firm bidding outside of its usual territory cannot be penalized by being selectively bid up. This makes it much harder to maintain collusive agreements, especially the type that say, "I won't bid against you if you don't bid against me."

The proposed bidding system is less effective in eliminating the incentive to collusive bidding provided by the ability to raise the bid if an outsider enters the bidding, or if a member of the agreement bids more than agreed. This case is discussed in the Appendix.

Thus simulated oral bidding will achieve the efficiency gains of oral bidding while reducing the risk of collusive bidding. Whether it will yield more or less revenue depends on the circumstances, although when profit taxes, individual income taxes, and inheritance taxes are included it is likely that seeking economic efficiency will also produce the highest total revenue to the government.

OTHER FEATURES OF SIMULATED ORAL BIDDING

The simulated oral bidding procedure yields information on the willingness to pay of timber users rather than just a series of values

for the amounts that they did pay. This willingness is the sum of the amount paid and their economic profit (revenue minus a marginal cost including the minimum return on capital required). There are many uses for this information. One that has already been mentioned is in setting refusal prices in cases of suspected collusion.

The increment in gross national product resulting from the processing of timber is the willingness to pay revealed by the proposed bidding system. The optimum timber management policy requires that investments in timber production be made if the increase in national income exceeds the cost of the investment. The proposed bidding system generates the information needed for implementation of this principle.

The sales values resulting from implementation of either a simple oral or sealed bidding system are less useful in guiding forest management policy. Where there is collusion both oral and sealed bids will understate the real value to the economy of standing timber. If there is only one purchaser, perhaps because of the location of the timber, oral or sealed bids understate the value of the timber. In other cases traditional bids reflect not only estimates of the "value" of timber but estimates of the amounts other firms would be willing to offer. These estimates of potential competition tend to be highly variable. The result is that amounts actually bid may not even be proportional to the value of the timber as estimated by the different firms. The resulting prices will not be accurate indications of the values of different stands, and the priority that should be accorded to protecting and improving them. The basic problem with using the amount bid is the exclusion of the expected "economic" profit from processing the timber. Use for management purposes of a measure of willingness to pay eliminates this difficulty.

ADMINISTRATIVE COSTS

The administrative costs of simulated oral bidding should be low. Because the bids are written there is no need to send expensive personnel to the auction sale. Indeed, the cost of bidding may be lower than for sealed bidding. With sealed bidding, it is necessary to first determine the maximum one is willing to pay for a parcel, and then evaluate the strength of the competition before bidding. With simulated oral bidding, one need only estimate the maximum one is willing to pay.

INTERDEPENDENCE BETWEEN BIDS

Where a number of parcels are being sold, both simulated oral bidding and sealed bidding make it difficult to purchase the amount

desired. With bids on all parcels, there is the risk of having purchased more than is wanted or can be paid for. With bids on just a few, there is the risk of winning none. This problem is especially serious for small firms which may lack the ability to handle more than a few parcels.

The essence of the problem is that the amount that a firm is willing to pay depends on how much it has already purchased. With conventional oral bidding a firm can adjust its bidding to the success it has already enjoyed. When it has won all it wants, it may stop bidding or reduce its bids. Likewise, if it is winning less than expected it may increase the level of its bidding.

The solutions for this problem are basically the same for both sealed and simulated oral bidding. The simplest is not to offer a large number of parcels at one sale but to hold frequent smaller sales. Even within one day, a large sale may be broken into a number of smaller sales with the bid openings being spaced far enough apart to permit bids to be changed in response to the outcome of earlier sales.²⁰ Another possibility is to tabulate the amount purchased by each of the bidding firms and to allow each firm to provide a maximum limit for its purchases. Once this limit has been reached, all other bids by that firm are disregarded.

BIDDING METHODS AND BIDDER APATHY

The problem of bidder apathy is almost a necessary consequence of an efficient bidding system. Any system which consistently leads to the most efficient firm winning the sale will prove discouraging to the less efficient firms. With oral bidding and simulated oral bidding the firm with the highest willingness to pay will always win. This is likely to lead to other firms dropping out as soon as they perceive that they will not win.

The problem of bidder apathy is not serious with sealed bidding. As indicated above, the profit maximizing strategy for the efficient firm involves bidding low enough so that it will occasionally be outbid by other firms. These occasional victories by the less efficient firms will give them an incentive to continue bidding.

Bidder apathy is reduced but not eliminated by sealed bidding. The profits to the less efficient firm from only an occasional victory may be less than the cost of bidding in all sales. When this happens, the less efficient firm drops out of the bidding due to apathy. The risk that the efficient firm may adopt a strategy of consistently bidding high in the hope that other firms will stop bidding is small.

20. Of course, this requires that the closing times for submitting bids for one sale be after the announcing of the winners for the earlier sale.

For the efficient firm to benefit from this strategy it must eventually lower its bids or be so successful that the competition is driven out of business.²¹ These lower bids will, in turn, attract the competition back.

If the cost of submitting a bid is a , and the expected profit from having the bid prove successful is b , the firm will bid as long as the probability of winning exceeds a/b . With a probability of success lower than this, the profit maximizing strategy is not to bid. Thus, the problem of bidder apathy can be reduced by reducing the cost of submitting bids.

There are many ways the cost of bidding can be reduced. The current Forest Service procedure requires that bidders qualify for a sale by first submitting a written bid equal to at least the appraised price of the timber. This raises the price of bidding and increases the risk of bidder apathy. On the other hand, having the government cruise the timber and announce the quantity involved can eliminate the cost of each private firm cruising the timber.²² Deposits should be limited to the absolute minimum. Permanent deposits applicable for all sales, or contracts providing for recourse against fixed assets of bidders who do not honor their bids can be used. These reduce the marginal cost of qualifying for a particular sale to zero for most firms. They encourage firms with only a small expectation of winning to submit bids. Auctions at which several parcels are sold may encourage firms to bid on parcels they do not expect to win. If the firm must have a representative present in any case, the added cost of bidding on timber that has already been Federally cruised may be negligible. An effort by the Federal government to reduce the cost of bidding would reduce the cases in which bidder apathy results in loss of revenue.

One way of reducing the cost of bidding would be to adopt a system of simulated oral bidding. This eliminates the need to send qualified representatives to the sale and encourages firms to bid on timber they do not expect to win. With simulated oral bidding it would be desirable to keep the identity of unsuccessful bidders secret but make public the amounts bid. This protects them from worry about retaliation and encourages them to bid while providing an honesty check against the auctioneer.

With simulated oral bidding it is possible to supply an incentive for bidding even when a firm is certain it will not win. This can be done by offering a small cash reward to the second highest bidder (perhaps

21. And even here there is a substantial risk of new entrance as soon as the price bid is lowered to take advantage of the absence of competition.

22. Cruising is the process of estimating the value of standing timber.

a percentage of its bid). Because the bids are in a written form it is possible to determine who the second highest bidder is and pay him. With an oral auction such a payment would be impracticable. If the payment to the second highest bidder exceeds the cost of preparing a bid there will be at least two bidders (assuming that there are at least two firms willing to pay at least the appraised price for the timber). Competition among firms for the payment to the second highest bidder will serve to raise the level of these bids and hence to raise the revenue from sale of the timber to the highest bidder. Thus simulated oral bidding can be modified to eliminate the problem of bidder apathy.

BIDDING SYSTEMS FOR PETROLEUM AND OTHER MINERAL LEASES

Most of the discussion so far can be applied to sales of mineral resources as well as to timber. However, sales of minerals typically have features which influence the type of bidding employed. One is that only part of the Federal revenues come from bonuses, the bulk of the remainder come from royalties. The Federal government collects as royalties an eighth of the value of petroleum produced from the onshore public land, and a sixth of the value of production from the offshore lands. In 1971 the United States government collected the appreciable sum of \$265,900,000 in oil and gas royalties.²³ Thus the maximization of Federal revenues requires considering not only the amounts paid initially for the leases, but the expected values of future royalties. These are determined by the amount of production from the lands, and indirectly by the amount of exploration.

There is a wide variation in estimates of the probability of finding petroleum on different leases. This is evidenced by the large difference typically found between the winning and the second highest bid for mineral leases. Mead has reported that for oil and gas lease sales the ratio of the high to second highest bids averaged 1.91.²⁴

While part of the variation may be due to differences in estimates of the competition, it is likely that the most important factor is differences in the estimated chance of finding petroleum, and the size of discovery expected. It is desirable to award leases for unexplored lands to the firm which has the most ambitious exploratory program, and which presumedly is the most likely to find oil. One way to do this is to require all bidders to commit themselves to exploratory programs in advance, and then to select the firm with

23. U.S. Dep't of the Interior, Bureau of Land Management, Public Land Statistics, Table 114 (1971). Virtually all of the Geological Survey receipts deposited to the Bureau of Land Management accounts represent royalties.

24. Mead, *supra* note 15, at 212.

the most ambitious programs. This is administratively difficult as a large number of plans must be examined in detail, and there is usually scope for dispute as to which is most likely to be successful.

Such an "exploratory effort" bidding can also be very inefficient. Firms may commit themselves to conduct more than the optimal amount of exploration. For instance, a well-defined structure may require only a single well for testing, but if the chances of that well being successful are high enough, firms may promise a second unneeded well in order to win permission to drill the first well. An efficient exploratory program must be a highly flexible one with the strategy being constantly adjusted to the results from earlier stages. With "exploratory effort" bidding there are likely to be times when the results of the first wells or the initial seismic work suggest that further expenditure is not justified, but the firm has committed itself to doing more. The problems with "exploratory effort" bidding lead one to search for a better way of discovering which firms will conduct the most energetic search for oil.

The firms most likely to conduct an ambitious exploratory program are generally those who are most optimistic about finding oil. This optimism may be measured by their estimates of the expected value of the profits from the tract. The expected value of profits is not only a determinant of exploratory effort, but, as indicated above, it is also a determinant of the amounts that will be bid for leases. Thus, competitive bidding will be an efficient way for assigning exploratory rights to firms that will look hardest for the oil. This is a powerful argument for assigning leases by competitive bidding instead of the non-competitive system used for most of the public domain.²⁵

However, some methods of competitive sale are more effective than others in selecting firms likely to look energetically for oil. The expected profit from a tract is nothing but the firm's willingness to pay discussed earlier. As shown then both oral bidding and simulated oral bidding award the lease to the firm with the highest willingness to pay. These will be the firms with the most optimistic assessment of the chances of finding oil, and hence the most ambitious exploratory program. However, with sealed bidding there is a chance the

25. For most public domain lands which become available for leasing through expiration or relinquishment of leases a provision in the law requiring that the lease be issued to the first applicant has been interpreted such that all applications filed within a specified period are considered simultaneous and the successful applicant determined by drawing. These lotteries sometimes attract several thousand applicants with the bulk of the applicants intending to sell their leases if successful. The author discusses at great length the simultaneous filing system (as this method of non-competitive public land disposal is known) in *Study of Energy Fuel Mineral Resources* for the Public Land Law Review Commission, a Report by Abt Associates.

competition will be underestimated and the lease awarded to a firm not planning an ambitious exploratory program.

Consider the situation where one firm believes that the chance of finding oil is sufficiently good to justify sinking a well. Suppose it is competing with a less optimistic firm whose intention is merely to hold the lease undrilled in the hope that a nearby discovery would make the lease valuable. From the government's viewpoint it is desirable to get as many leases as possible into the hands of firms of the first type, for only if the leases are drilled does it have any chance of receiving royalties. Yet with sealed bidding there will be a certain number of cases in which the optimistic firm loses, and the speculator wins. This should not happen with either oral bidding or simulated oral bidding.

Thus, when selling exploration rights for minerals, the government will maximize royalty revenues (but not necessarily bonus revenues) if it uses oral or simulated oral bidding rather than sealed bidding. In addition, these two bidding methods serve to get the leases into the hands of the firm with the lowest costs, or highest potential returns. A firm may have unusually low costs because of possession of a drilling rig near the lease, or one suited to the specific conditions to be encountered. A firm may also have a cost advantage because of possession of adjacent leases. In general, costs will be lower, and recovery higher, if adjacent leases can be operated as a unit.

BIDDING SYSTEMS FOR PURCHASING GOODS

The arguments presented above in the context of sales of government-owned resources can be easily applied to purchases of goods and services. Here, the winner is the firm that submits the lowest bid. The lowest price a firm is willing to quote will usually be its marginal cost. Where there is substantial excess capacity this marginal cost may include little more than materials and labor. Where there is a shortage of capacity it will include a substantial premium for diverting production facilities from other uses.

The policy arguments dealing with purchases of goods and services are similar to those for sales of government-owned resources. There will often be differences between suppliers in their marginal costs. For bulky products such as cement or petroleum some suppliers will be better located than others. In many cases possession of special equipment or special knowledge will make a particular supplier the low cost one for filling certain orders. In other cases one firm is simply more efficient than the other firms because of more nearly optimal size, or better management. If the goal is to maximize na-

tional income it is necessary that production, including that for sale to the government, be done by the most efficient firms.

In general the government has an interest in having production for it done at the lowest marginal cost. The sellers of goods and services to the government are citizens whose welfare should be of interest to the government. Even if it isn't, the government as beneficial recipient of about half of corporate profits has a strong interest in awarding contracts to the firms most likely to make a profit. In addition, there are personal income taxes on dividends, capital gains taxes, and inheritance taxes to be considered.

When contracts are awarded using oral bidding or simulated oral bidding, the contract will go to the lowest estimate of its marginal cost.²⁶ This will usually be the firm with the lowest actual marginal cost and the highest potential profit. With sealed bidding, which is traditionally used for government procurement, there will be cases in which the order will not go to the firm with the lowest bid. Thus from the viewpoint of economic efficiency sealed bidding may be a poor way to award contracts.

It is impossible to say which bidding method will bring the government the lowest costs. In general, if the marginal costs of the bidders are close together and there is effective competition the best prices will probably result from oral, or simulated oral bidding. With bidders with widely differing marginal costs sealed bidding is likely to bring the best price. Here the most efficient firm is likely to bid above the marginal cost of the second most efficient firm. Where there are only a few bidders oral bidding may end in collusion.

APPENDIX: SIMULATED ORAL BIDDING, COLLUSION, AND OUTSIDE ENTRY

A likely bidding strategy for members of a bidding group is for the selected winner to make a high bid at the maximum amount he is willing to pay, and then for the other firms to make no bids or token bids. If no non-member bids, the selected firm will win the bidding and will pay a low price for the timber. If a non-member enters the bidding the selected winner may still win but he will have to pay the amount that the outsider was willing to pay if such an outside bid exceeds the second highest collusive bid. This is different from the situation with sealed bidding where the member of a bidding group is bidding low because he must pay the amount he bids. Here, there is always a risk that a non-member of the group will enter the bidding and win. This deters attempts to take the timber with extremely low bids.

However, the members of the bidding group may not adopt the strategy of having the firm selected to win bid high. It is suspicious for a firm to bid as if it was desperate for timber at one time and then not to bid at all at other times or to submit only a token bid. Such behavior will serve as a sign to antitrust authorities that there is probably a bidding

26. The relevant marginal cost may or may not include the cost of capital depending on whether there is excess capacity at the time.

agreement, and will encourage those responsible for setting minimum acceptable prices to set high prices.

To avoid these responses the members of the bidding agreement may reduce their maximum bids. Once this is done they are no longer certain of winning if an outsider enters the bidding. This will in turn lead them to raise their second highest bids to reduce the profits which such an outsider would receive, and hence to reduce the outsider's incentive to bid. The final effect is to compress the margin between the high bid (which determines who wins) and the second highest bid (which determines how much he pays): as these two bids come closer together the bidding pattern comes to resemble that with sealed bidding in which the limit to the power of a bidding group is set by fear of entry of non-members.

However, defense against collusive bidding rests only partially on the bidder's own behavior. Because firms are revealing their maximum willingness to pay information is available to set refusal prices which leave only a small margin for collusion. Because a firm does not pay the amount of its maximum bid it is willing to reveal its willingness to pay. Thus the government can set a refusal price a bit below the typical maximum bid. The motive of not encouraging the government to raise its refusal price will be weak as long as any one firm wins only a small fraction of the sales, and bears only a small fraction of the costs arising from an increase in the government's refusal price. It will be much more concerned with assuring that it buys the timber desired than protecting the interests of the "industry" in a low government refusal price. Indeed, as long as sales are competitive, the government refusal price is likely to be below the second highest bid where it has no effect on the actual sales price.

However, if the actions of a bidding group produce a situation in which the second highest bid is consistently far below the highest bid (suggesting collusion), although different firms are making the high bids, the government may take this as a signal to raise its refusal price. For instance, if in a particular area the high bids were consistently \$35-\$45 regardless of who submitted the high bid, and the other bids clustered around \$5-\$10, the government would have a clear sign that it could raise its refusal price without much risk of not selling the timber. This differs from the situation with sealed bidding where prices would be low and would give no indication that more could be charged. (As discussed earlier, if bidders attempt to limit their maximum bids they run a risk of being outbid by outsiders and the situation resembles that in sealed bidding.)

It should be noted that to the extent that firms limit their bids in order to prevent the government from raising the refusal price, the ability of the bidding system to sell the timber to the most efficient firm is reduced. A less efficient firm may purchase the timber with a higher bid. However, with a competitive situation a firm is unlikely to lower its maximum bid for the sake of discouraging the government from raising its refusal price if there is much chance that this would cause it to be outbid.²⁷ A bidding group whose members bear all the private loss from increases in the refusal price has a stronger incentive to reduce their bids. However, the efficiency loss from this behavior is likely to be small because which mills get which timber is being decided within the group rather than through operation of the bidding system.

Only in the case where a large and consistent gap between the highest and second highest bids is due to there being a single firm for which timber is unusually valuable (perhaps because of location in relation to the mill) will a policy of raising the refusal price be likely to lead to inefficiencies. This situation can be recognized by the same firm consistently being the high bidder, in contrast to the bidding group situation where this position is rotated. The high bidder, because he bears the entire loss from any increase in the refusal price, has a strong incentive to conceal his willingness to pay by bidding low. At worst, a lower limit to his bids is set by the threat of being outbid by other firms. In this limiting case his bidding strategy becomes identical to that which he would follow if sealed bidding was being used, and the efficiency losses are the same. These losses can be avoided by a government policy of not raising refusal prices in cases of this type.

27. This is because it bears all of the cost of being outbid, but only part of any losses from having the government's refusal price raised.