DOES SEALED BIDDING PROMOTE COMPETITION IN THE AUCTIONING OF PUBLIC TIMBER?

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ABSTRACT

The USDA Forest Service increasingly relies upon sealed bidding in lieu of oral auctions because of a perception that sealed bidding increases timber sale competition. This paper introduces a comprehensive approach for expressing and estimating the extent that a change from oral to sealed-bid auctions will increase competition through 1) a participation effect of attracting more bidders to a given auction, and 2) a substitution effect of soliciting higher overbids from a given pool of bidders. We develop a framework that expresses these two effects in a single Slutsky-like function. Using the Forest Service's Rocky Mountain Region as a study site, we apply the Slutsky framework using regression techniques. For the substitution effect, we found that bidders changing from oral to sealed auction bid more aggressively as they increased the overbid by an average of $1.77/CCF. For the participation effect, we found that sealed-bid actions attracted an average 0.28 more bidders, increasing the overbid by an additional $1.68/CCF. These results show unambiguously that sealed bidding promoted Rocky Mountain Region sale competition by an average $3.45/CCF per sale.

Keywords: Auctions, oral, sealed, slutsky.

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INTRODUCTION

National Forests and other U.S. public timber owners regularly offer timber for sale using one of two auction processes: the oral-style English auction or the first-price sealed-bid auction. The USDA Forest Service increasingly relies upon the sealed-bid auction because of a perception that it improves bidding competition. This perception originated with studies by Weintraub (1958) and Mead (1966) who suggested that oral auctions limited sale competition, as measured by the number of active bidders and the inclination of those bidders to make high bids.

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Subsequent studies of the auction process applied to the Forest Service's Douglas-fir Region (Mead, 1967; Weiner, 1969 and 1979; Johnson, 1979; Mead *et al*., 1981) found that sealed-bids attracted more bidders and generated higher winning bids than oral auctions. However, a more recent study by Hansen (1986) showed that non-randomized methods of selecting the auction type may have biased the results of previous investigations. He found that choice of sale method was often based upon sale characteristics such as volume offered, adjacency to dependent communities, and date offered.[1] After adjusting for this selection bias, Hansen (1986) measured no significant difference between oral and sealed bids. Following Hansen's example, Schuster & Niccolucci (1994) analyzed timber auctions in the Forest Service's Northern Region. They concluded that sealed-bid sales generated higher winning bids when the auction method had been chosen randomly, but that oral auctions generated higher bids when the auction method was chosen based on sale characteristics.

While early studies did not adjust for the non-random selection of auction method, the recent investigations by Hansen (1986) and Schuster & Niccolucci (1994) did not account for the potential impact of auction method on bidder participation. For example, Schuster and Niccolucci's application did not address bidder participation. Although Hansen's (1986) model included participation, it did not allow for the possibility that different auction methods might attract different levels of bidder participation. Not accounting for the potential effect of auction method on bidder participation may explain the ambiguous results of these studies.

We introduce a more comprehensive approach to estimate the extent that a change from oral to sealed-bid auctions will increase competition through 1) a participation effect of attracting more bidders to a given auction, and 2) a substitution effect of soliciting higher overbids from a given pool of bidders. Our approach builds on previous models by expressing these two effects in a single Slutsky-like function. The function combines the participation and

[1] Mead (1966) and Weiner (1969) also noted a relationship between sale volume and auction method, but did not suggest corrections for the problem.

substitution effects into a single expression of the overall effectiveness of sealed bidding in promoting timber sale competition. Two separate regression equations are applied to estimate the elements of participation and bidding.

METHODS

The overall model of the effect that auction method has on sale competition is denoted in (1) where overbid is expressed as a function of the auction method (m = oral or sealed) and of the number of bidders (N) attracted to a given auction method (m) and a given set of sale characteristics (sc):

$$Overbid = f\,[m,\ N(m,sc)] \tag{1}$$

Overbid is defined as the amount (measured in dollars per hundred cubic feet, $/CCF) over the appraised price a purchaser is willing to pay. Although there are several measures of timber sale competition, overbid is a common proxy (Haynes, 1979).

To find the change in overbid that will result from a change in auction type, we take the partial of equation (1) with respect to sale method:

$$\frac{\Delta Overbid}{\Delta m} = \underbrace{\frac{\Delta Overbid}{\Delta m}\Big|_N}_{Substitution} + \underbrace{\frac{\Delta Overbid}{\Delta m} * \frac{\Delta N}{\Delta m}}_{Participation} \tag{2}$$

The partial produces a Slutsky-like expression comprised of participation and substitution effects. It is expressed in a discrete form because the number of auction participants will always be a number of individuals. The substitution effect in (2) denotes the change in overbid that would occur if N bidders (shifting from oral to sealed-bid auction) bid differently under the two auction methods. This substitution effect is decomposed for econometric purposes as:

$$\frac{\Delta Overbid}{\Delta m}\Big|_N = \left[\frac{\Delta Overbid}{\Delta N_s} - \frac{\Delta Overbid}{\Delta N_o}\right] * N \tag{3}$$

In (3), the subscripts *s* and *o* are introduced to denote participation in sealed and oral auctions, respectively. The term $[\Delta Overbid/\Delta N_s]$ denotes the marginal value of a bidder to a sealed-bid auction while $[\Delta Overbid/\Delta N_o]$ denotes the same for oral auction. The difference between these marginal values denotes the change in overbid that an additional bidder would bring from the change in auction method. Multiplying by N denotes the change in overbid ($/CCF) that N bidders would produce by changing to sealed-bid auctions.

The participation effect in (2) is composed of two parts: $[\Delta N/\Delta m]$ denotes the effect that changing the auction method would have on participation; and $[\Delta Overbid/\Delta N]$ denotes the effect this change in participation would have on the bid. Multiplied together, they express the participation effect on the overbid that would be expected by changing from oral to sealed bids.

It is possible to obtain an ambiguous result for (2) if the participation and substitution effects are opposite, i.e. one is positive and the other is negative. The outcome will be ambiguous if one auction method is more effective in drawing participants, but less effective in generating high bids from its participants. A consistent result will be generated only if one auction method is more effective at both. Such an auction method would be considered to unambiguously promote timber sale competition.

Econometric Analysis

Equation (1) expresses the overbid as a nested function of participation. To keep the substitution and participation effects separately identifiable, two regressions [paralleling the structure of equation (1)] are applied. One regression estimates overbid as a function of auction method and participation — and the other identifies the separate effect of auction method on participation. Results of the two regressions are then combined to operate equation (2). To perform the two regressions and related tests of significance, we obtained data records[2] for 338 timber auctions in the USDA Forest Service's Rocky Mountain Region (Colorado, Wyoming and North Dakota) during Fiscal Years (FY) 1990-

[2] Data were provided by USDA Forest Service 2400-17 sale summary records.

94. These records include all transactions evidence appraised[3] sawtimber sales that were at least $2,000 in value. Of the 338 records included in the database, seventy one were for oral auctions. These oral auctions were evenly distributed over the FY 1990-94 period.

The first regression (4) is intended to estimate the effect of auction method on bidder participation while controlling for variation in sale characteristics:

$$N = \gamma_0 + \gamma_m d_m + \sum_{i=1}^{n} \gamma_i X_i + \varepsilon \tag{4}$$

where N is the number of active bidders, d_m is a dummy variable representing the method of sale (0 for oral, 1 for sealed-bid), X_i is a vector of sale characteristics affecting participation, and ε is an error term.

The coefficient γ_m estimates the $[\Delta N/\Delta M]$ partial in (2) by measuring the change in participation when sealed bidding is used in lieu of oral auction. If sealed bidding increases the number of auction participants, γ_m will be positive. The coefficients denoted by γ_i estimate the number of participants attracted to sale characteristic (i). Sale characteristics might include physical properties (such as species and volume mixes) and market factors (such as lumber prices). Including such characteristics in the regression attempts to avoid the auction method selection bias identified by Hansen (1986). We have chosen to include the percent quarterly change in the WWPA white woods lumber price index (X_{wwi}) and dummy variables for a Black Hills National Forest sale (X_{bh}), a set-aside sale (X_{sba}), a sale of predominantly dead material (X_{dead}), a sale of predominantly lodgepole pine timber (X_{lpine}), and a sale of predominantly douglas-fir timber (X_{dfir}). The coefficient γ_0 estimates $[N]$ for equation (3) by measuring the average number of bidders "before" adjusting for auction method and sale characteristics.

[3] Transactions evidence appraisals use previous sales of similar sale characteristics and comparable market conditions to estimate the value of current sales. Chapters 50 and 60 of the USDA Forest Service Handbook 2409.22 describe this appraisal process for Region 2.

A second regression estimates the impact that participation (measured by number of bidders) has on bidding competition (measured by overbid) for each auction method. Establishing a substitution effect requires that participants bid differently per auction method. Equation (5) captures the marginal increase in overbid from adding one more bidder to an oral or sealed-bid auction respectively:

$$Overbid = \beta_o N_o + \beta_s N_s + \varepsilon \quad (5)$$

where *Overbid* is the amount over the appraised price the purchaser was willing to pay ($/CCF), N_o is the number of active bidders in the oral auction (0 if not oral), N_s is the number of active bidders in the sealed bid auction (0 if not sealed), and ε is an error term.

The coefficients β_o (oral) and β_s (sealed) estimate $[\Delta Overbid/\Delta N_o]$ and $[\Delta Overbid/\Delta N_s]$, respectively, in equation (3). Because we assume a change from oral to sealed-bid auctions, β_s also estimates $[\Delta Overbid/\Delta N]$ in (2). We expect these coefficients to be positive, reflecting that increased participation promoted higher bids. If sealed bidding is more effective in drawing high bids from auction participants, β_s will also be significantly greater than β_o. Because overbid is calculated as the high bid minus the appraised value, using overbid again attempts to avoid potential bias from the auction method selection process and measures only that portion of the winning bid resulting from bidding competition (Weiner, 1979; Schuster & Niccolucci, 1994). We set the intercept at zero because sales with zero active bidders are usually sold to an inactive bidder at the appraised value (i.e., zero overbid).

RESULTS

Three oral-auction sales (with overbids greater than $50/CCF) and five sealed-bid sales (with overbids greater that $60/CCF) were identified as outliers in both regressions and were removed. The remaining 330 sales were found to have heteroscedastic error disturbances as variations in sale characteristics and sale overbids increased with bidder participation. This is known to produce consistent and unbiased coefficients, but biased estimates of coefficient error. We corrected for the heteroscedasticity using White's

TABLE 1. INFLUENCES ON BIDDER PARTICIPATION.
Measuring the influence of auction method and sale characteristics on bidder participation in the Rocky Mountain Region (FY 1990–94).

Dependent Variable	=	Number of Active Bidders (N)
Number of Observations	=	330
R^2	=	0.162
Standard Error of Regression	=	1.127
F –ratio	=	8.888
F –significance	=	0.000

COEFFICIENT	VALUE	STD. ERROR	T –RATIO	$P(\gamma_i = 0)$
γ_0	1.505	0.061	24.557	0.000
γ_m	0.280	0.067	4.200	0.000
γ_{wwi}	1.968	0.531	3.709	0.000
γ_{bh}	0.666	0.135	4.941	0.000
γ_{sba}	–0.474	0.124	–3.820	0.000
γ_{dead}	0.509	0.206	2.466	0.014
γ_{lpine}	–0.366	0.109	–3.370	0.001
γ_{dfir}	–0.864	0.165	–5.244	0.000

method of recalculating the standard errors using actual data residuals in substitution for the regression's predicted data error (Pindyck & Rubinfeld, 1991).

Table 1 lists the results for regression equation (4). The strong significance of γ_m suggests there was a participation effect when changing to sealed bidding. The estimated value of γ_0 indicates an average 1.5 bidders will participate irrespective of the auction method (and sale characteristics). The estimation of γ_m suggests that sealed bidding increased this participation by an additional 0.28 bidders per auction. Results for regression equation (5) are listed in Table 2. The high levels of significance for β_o and β_s indicate a strong positive relationship between the number of participants and the overbid for each auction method. These coefficient values indicate that the addition of a bidder increased a sale's overbid an average \$6.01/CCF for sealed bids and \$4.83/CCF for oral auctions. Both regression's F-statistics are highly significant.

Results from a t-test for $\beta_o > \beta_s$ suggests there was also a substitution effect when changing from oral to sealed. The t-test produced a 97% probability that sealed-bid auctions

TABLE 2. INFLUENCES ON SALE OVERBIDS.
Measuring the influence of auction method and sale characteristics on sale overbids in the Rocky Mountain Region (FY 1990–94).

Dependent Variable	=	Overbid ($/CCF)
Number of Observations	=	330
R^2	=	0.607
Standard Error of Regression	=	9.884
F-ratio	=	254
F-significance	=	0.000

COEFFICIENT	VALUE	STD. ERROR	T-RATIO	$P(\beta_i = 0)$
β_o	4.830	0.633	7.631	0.000
β_s	6.011	0.401	14.995	0.000

generated higher bids for a given number of participants. We calculated a t-statistic of t_0 = 1.8892 with an associated probability of $P(\beta_s > \beta_o) = P(t > 1.8892) = 0.97$.

To estimate the overall effect of changing to sealed bid-auctions, we substitute the results from the regression equations into the participation and substitution components of equation (2). The participation effect of changing to sealed bidding is calculated as the increment in participation from changing to sealed bidding (0.28) times the contribution of those participants to the overbid ($6.01) which equals $1.68/CCF per auction. The substitution effect of changing a sale to sealed-bidding is calculated as the difference in the contribution that additional bidders make to sealed vs. oral overbids ($\beta_s - \beta_o$) times the number of bidders affected (γ_0). The estimated substitution effect is then $1.77/CCF per auction [(6.01–4.83)∗1.5]. Together, the substitution plus the participation effect suggest that sealed-bid auctions would have generated an average $3.45/CCF more per auction.

DISCUSSION

The Slutsky-like function provides a potentially generalizable approach to measuring the effects of changing auction methods. By incorporating the substitution and participation effects, it provides a comprehensive framework for the ideas originally presented by Weintraub (1958) and Mead (1966). In early studies, Mead (1967), Weiner (1969 and 1979) and Mead *et al*. (1981) attempted to meas-

ure the two effects independently. In later studies, Hansen (1986) and Schuster & Niccolucci (1994) did not address the participation effect. An important feature of the Slutsky-type framework is that it allows for varying outcomes for both effects. For example, one auction method could be better at attracting participants while the other might be more effective at soliciting bids from its participants.

Results from the Rocky Mountain Region unambiguously indicate that changing to sealed bidding promoted timber sale competition. Our estimates show that changing to sealed-bid auctions increased bids by an average of $3.45/CCF per sale. This was comprised of an average increase of $1.77/CCF because bidders changing from oral to sealed bid more aggressively and by an average of $1.68/CCF because oral auctions attracted an average 0.28 more bidders. These results apply only to the Rocky Mountain Region and are not generalizable. However, the generalizable Slutsky framework provides a basis for testing the effectiveness of alternative timber auctioning methods in other locations.

Potentially important questions remain concerning why sealed-bid auctions produced more competitive results in the region. For example, sealed-bid auctions could have drawn more active bidders because they have lower transaction-type costs (bidders could participate without being present). We would expect this to benefit more distant bidders the most. Sealed-bid auctions may also have drawn more aggressive bids for reasons described by Mead (1966) associated with collusion, or for reasons associated with the "winner's curse" described by Milgrom (1981). In oral auctions, each participant is revealed and each participant often knows the bidding habits of others. Participants may be able to take advantage of this information. By separating substitution and participation effects, the Slutsky-like framework may enable a richer analysis of these and other timber auction issues.

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