MULTIPLE-WINNER AWARD RULES IN BUYER-DETERMINED ONLINE REVERSE AUCTIONS

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INTRODUCTION

The industrial marketplace has witnessed the growing use of online reverse auctions, a common procurement pricing mechanism. Global revenues from electronic supplier management and procurement tools grew 17% on an average annual basis from $2 billion in 2004 to a forecasted $4.5 billion in 2009 (Forrester Research 2008). Despite the economic stakes and growing academic interest in this area, significant theoretical issues remain, particularly in regard to the design and management of these mechanisms.

A distinguishing feature of online procurement auctions is that the award allocation is typically *buyer-determined* (Jap 2002), in contrast to traditional auctions, in which the bidder with the highest/lowest bid is declared the event winner. The buyer-determined format introduces a range of possible bidding strategies for suppliers that are yet to be explored. In particular, a dominant bidding strategy might be to bid low enough to remain in the buyer's final consideration set, without necessarily being the lowest price bidder.

In this research we investigate the use of *multiple winner award rules*, which explicitly specify the number of suppliers who could win a portion of the total contract volume. For example, a buyer might declare that a contract will be awarded to two firms, the first of which will be asked to supply 70% or 80% of the total requested volume, and the second firm would supply the remaining 30% or 20%. Or a buyer might use a 40/30/20/10 rule, in which each supplier provides 40%, 30%, 20%, and 10% respectively of the desired total volume. This mechanism represents a hybrid approach to determining the auction winner, providing the buyer the flexibility to take into account quality differences in its selection process, while reducing the perception that the winner selection is arbitrary or opportunistic (e.g., Jap 2003, 2007). Multiple winner award rules also enable a range of benefits for buyers including, reducing the hold-up potential associated with small numbers bargaining, testing the capabilities of new suppliers, or broadening relationships with existing suppliers by training them to take on new lines of business.

Our focus is on how the buyer's use of such award rules impact the supplier's bidding behavior. Specifically, we consider how changes in (i) the number of bidders considered for the award, (ii) the proportion of those considered who are actually awarded contracts, and the (iii) stakes associated with multiple winner award rules in full price visibility[1] auctions impact the (i) bidders' participation decision and the timing of their initial bids, (ii) how quickly they respond to other bidders' bids (i.e., responsiveness), and (iii) the economic price savings offered (i.e., aggressiveness) to the buyer. To the best of our knowledge, we are the first to investigate how such hybrid mechanisms impacts bidding behavior and economic performance. Further, we examine the bidding behavior of experienced bidders relative to inexperienced bidders. Bidding experience is a critical aspect of bidding behavior (Wilcox 2000), and is particularly relevant in industrial exchange, as transactions are generally repeated over time and the economic stakes of each transaction can be significant. We examine these possibilities via the data from 54 industrial online auctions involving 192 suppliers competing for over \$73 million in purchase contracts over a three year period.

MULTIPLE WINNER AWARD RULES

In any B-D auction (i), suppliers are typically prequalified and invited to bid. Suppliers are told how many winners ($nwin_i$) will be awarded a proportion of the contract, the number of bidders considered ($ncsd_i$) for these awards and the proportion of volumes allocated to each winner. As an example, a 70/30 rule implies that 2 winners will be awarded a portion of the business, with 70% going to one winner and the rest to the other. Our data set includes awarding rules of 100%, 50/30/20, 60/30/10, and 40/30/20/10, respectively. One can also consider the associated variance of allocation percentage from the average of that bidding rule ($vwin_i$). For example, the average allocation percentage for the bidding rule 40/30/20/10 is 25%, so the variance of this rule is $(40\text{-}25)\%^2 + (30\text{-}25)\%^2 + (20\text{-}25)\%^2 + (10\text{-}25)\%^2 = .05$. As this value increases, the gap between the large and small order allocation increases. The net effect of this might be to intensify competition since the potential payoffs are now polarized. In the development of hypotheses, we elaborate on how each of these aspects might impact bidder participation, strategy, and savings offered.

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[1] Visibility refers to the pricing information observable to the bidders; full price visibility means that bidders can view every bid over the course of the auction.

THE ROLE OF EXPERIENCE & EVENT PARTICIPATION

H1: Experienced bidders (relative to inexperienced bidders) are ***more*** likely to participate as the:

(a) total number of bidders considered ($ncsd_i$) or

(b) proportion of winners ($rwin_i$) selected increases;

but ***less*** likely to participate as the

(c) variance of allocation ($vwin_i$) increases.

THE INITIAL BID

H2: Experienced bidders (relative to inexperienced bidders) are more likely to submit their initial bid *late* as the:

(a) ratio of the number of bidders considered ($rcsd_i$) increases

but more likely to submit their initial bid *sooner* as the

(b) proportion of winners selected ($rwin_i$) and

(c) variance of allocation ($vwin_i$) increases

BIDDING BEHAVIOR

H3: Experienced bidders (relative to inexperienced bidders) are ***more*** likely to respond quickly to bid prices as the:

(a) proportion of winners selected ($rwin_i$) increases

but are ***less*** likely to respond quickly to bid prices as the

(b) ratio of the number of bidders considered ($rcsd_i$) and

(c) variance of allocation ($vwin_i$) increases.

H4: Experienced bidders (relative to inexperienced bidders) are ***more*** likely to bid aggressively as the:

(a) proportion of winners selected ($rwin_i$) increases,

but are ***less*** likely to bid aggressively as the

(b) ratio of the number of bidders considered ($rcsd_i$) and

(c) variance of allocation ($vwin_i$) increases.

MODEL & EMPIRICAL ANALYSIS

We build the models for bidding behaviors for four aspects: event participation, initial bidding time, bidding responsiveness and aggression. Table 1 lists the notation.

Following Bajari and Hortacsu (2003), Bradlow and Park (2007), we model the number of participate bidders N_i in auction i as a Poisson distribution. To see how award rules affect the participation decision of potential experienced and inexperienced suppliers differently, we model the number of experienced and inexperienced participate bidders separately

$$\log(\eta_i^e) = \alpha_0^e + \alpha_1^e ncsd + \alpha_2^e rwin_i + \alpha_3^e vwin_i + \alpha_4^e p_i^r + \alpha_5^e T_i + \alpha_6^e PRDT_i + \alpha_7^e PUBLIC_i \qquad (1)$$

and

$$\log(\eta_i^{ie}) = \alpha_0^{ie} + \alpha_1^{ie} ncsd + \alpha_2^{ie} rwin_i + \alpha_3^{ie} vwin_i + \alpha_4^{ie} p_i^r + \alpha_5^{ie} T_i + \alpha_6^{ie} PRDT_i + \alpha_7^{ie} PUBLIC_i \qquad (2)$$

Similarly, the responding time Δt_{ij}^k by each supplier j in auction i is also assumed to follow an exponential distribution with parameter τ_{ij}^k. We model the parameter τ_{ij}^k to be a function of winning rules, auction-dynamic variables and auction-specific variables. Specifically, we model

$$\begin{aligned}\log(\tau_{ij}^k) = {} & \lambda_0 + \lambda_1 ncsd_i + \lambda_2 nwin_i + \lambda_3 vwin_i + \lambda_4 EXP_{ij} + \lambda_5 ncsd_i * EXP_{ij} + \lambda_6 nwin_i * EXP_{ij} \\ & + \lambda_7 vwin_i * EXP_{ij} + \lambda_8 (k-1) + \gamma_9 p_i^{k-1} + \lambda_{10}(T_i - t_i^{k-1}) + \lambda_{11}\Delta t_i^{k-1} + \lambda_{12} nb_{ij}^{k-1} \\ & + \lambda_{13} p_i^r + \gamma_{14} T_i + \lambda_{15} PRDT_i + \lambda_{16} PUBLIC_i .\end{aligned}$$

We then define the mean concession μ_{ij}^k to be a function of award rules, auction-dynamic and auction-specific variables. That is,

$$\begin{aligned}\mu_{ij}^k = {} & \gamma_0 + \gamma_1 rcsd_i + \gamma_2 rwin_i + \gamma_3 vwin_i + \gamma_4 EXP_{ij} + \gamma_5 rcsd_i * EXP_{ij} + \gamma_6 rwin_i * EXP_{ij} \\ & + \gamma_7 vwin_i * EXP_{ij} + \gamma_8 (k-1) + \gamma_9 p_i^{k1} + \gamma_{10}(T_i - t_i^{k-1}) + \gamma_{11}\Delta t_i^{k-1} + \gamma_{12} nb_{ij}^{k-1} \\ & + \gamma_{13} p_i^r + \gamma_{14} T_i + \gamma_{15} PRDT + \gamma_{16} PUBLIC_i .\end{aligned}$$

Our data were collected from one of the largest companies that specializes in hosting online B2B procurement auctions in China. Besides hosting the auction platform, the firm proactively matches buyers and sellers and trains the participants on the auction software. The objects procured through the auctions in our dataset had a total value of over 500,000,000 RMB (approximately $73,156,000) in 2004, which represented approximately 25% of the firm's total volume through these auctions (Jiang 2008). The dataset contains 54 auctions held over the course of a three year period (2002 to 2005) and contains complete bidding information as well as the award rule, starting and ending time for each auction. The purchasing contracts were for packing boxes, cellular phone cases, personal computers, cables, circuit boards, chemicals, medicines, water purification equipment, public buses and steel. A total of 192 suppliers participated and submitted 4456 bids. While there are some suppliers who participated in multiple auctions (e.g., two or three auctions), 81% of them participated in only one auction. The number of suppliers that participated in each auction range from 2 to 12, with an average of 5 suppliers participated in each auction.

KEY RESULTS

The decision to participate. Our results indicate that bidders are more likely to participate in auctions where the potential payoffs are straightforward .We also find that the decision to participate differs markedly for experienced and inexperienced bidders. Instead of shying away from auctions with multiple winners, experienced bidders see the potential to grab a share of the contract award.

Initial bid activity. Initial bids tend to occur later rather than sooner, when the consideration set size and proportion of winners from this set increases. Experienced bidders demonstrate a more nuanced strategy, however: when the proportion of winners from the consideration set or the variance of allocation increases, then experienced bidders are more likely to accept the downside risk of increased competition and submit their initial bid earlier than inexperienced bidders.

Bidding response and aggression. Our results imply that multiple winner award rules encourage responsive bidding and increases the savings offered by bidders. As the proportion of winners selected from the consideration set increases, bidders become more aggressive and offer larger price savings. As the variance of award allocation increases, the disparity in awards encourages bidders to bid more quickly in response to previous bids.

However, we find that the use of multiple award rules significantly decreases their bid responsiveness and aggression. When do experienced bidders bid more responsively and aggressively? In short, only when the payoffs are worthwhile. Specifically, when the ratio of winners from the consideration set is high, experienced bidders will respond to prior bids quickly. And when the variance of award allocation increases, experienced bidders will offer price concessions, albeit at a low rate.

TABLE 1: Notation

Variable	Definition
Auction Characteristics	
nsp_i	Number of suppliers in auction i
T_i	Duration of auction i
p_i^r	Reserve price of auction i
$ncsd_i$	Number of suppliers chosen for the final consideration set in auction i
$nwin_i$	Number of suppliers who will win the contract in auction i.
$rcsd_i$	Ratio of the number of suppliers chosen among total number of suppliers in auction i, i.e., $rcsd_i = ncsd_i / nsp_i$.
$rwin_i$	The ratio of the number of winning suppliers among the number of suppliers chose in auction i.
$vwin_i$	Variance of award rule in each auction i. This is measured as the variance of allocation percentage from the average of that bidding rule. For example, under the bidding rule of 4:3:2:1, the average of that bidding rule is 25%, so the variance of that bidding rule is: $(40\%-25\%)^2 + (30\%-25\%)^2 + (20\%-25\%)^2 + (10\%-25\%)^2 = 0.05$
$PRDT_i$	Index for product category in auction i
$PUBLIC_i$	Dummy variable to indicate whether a buyer is a public or private company. PUBLIC = 1 if a buyer is public company; 0 otherwise.
Bidder Characteristics	
EXP_{ij}	$EXP_{ij} = 1$ if the bidder j in auction i is an experienced bidder; 0 otherwise.
Bidding Dynamics	
t_i^1	The initial bid time for auction i.
t_{ij}^k	Bid time of the j-th bidder at the k-th bid from the beginning of auction i.
Δp_{ij}^k	Incremental amount of j-th bidder's bidding price at the k-th bid in auction i.
Δt_{ij}^k	Response time of j-th bidder at k-th bid in auction i.
$k-1$	Total number of bids before the k-th bid was placed in auction i.
nb_{ij}^{k-1}	Total number of bids that the j-th bidder placed before the k-th bid in auction i.
$T_i - t_i^{k-1}$	Bidding time to the end of an auction when the k-th bid was placed.
p_i^{k-1}	Current bidding price when the k-th bid was placed.