SANDY D. JAP and ERNAN HARUVY

The authors model (1) the impact of the supplier's relationship propensity before the auction on the supplier's bidding aggressiveness in the auction (in terms of the number of bids it submits, the rate at which the bids are submitted, and the price concessions offered) and (2) the impact of bidding behaviors in the auction on the buyer-supplier relationship after auction through longitudinal survey data from 12 online reverse auctions across various product categories. The results suggest that incumbency, many bidders, and a willingness to make specific investments lead to less aggressive bidding, whereas the total number of bids from competing suppliers increases aggressiveness. In turn, aggressive bidding behavior reduces suppliers' disposition toward developing a relationship with the buyer and sours incumbent satisfaction with the relationship. Finally, auctions that are longer in duration can improve the relationship but may risk bidding competition. Collectively, the results suggest that pricing and relationships are intertwined and traded off against each other in complex ways and that the auction does not operate in isolation of key organizational variables.

Keywords: online reverse auctions, e-procurement, auction bidding behavior, buyer–supplier relationships

Interorganizational Relationships and Bidding Behavior in Industrial Online Reverse Auctions

Online reverse auctions, in which sellers bid prices down instead of buyers bidding prices up, are used across a wide range of industries (Fuller 2004), and their use is growing; even nonusers of these auctions indicate that they recognize they could be at a serious disadvantage unless they add these auctions to their mix of sourcing strategies (Beall et al. 2003). Academic interest in online reverse auctions is also on the rise, with growing streams of research on the benefits and risks of online reverse auctions (Mabert and Skeels 2002; Smeltzer and Carr 2003) as well as the performance implications of auction design choice, which are both economic (Carter et al. 2004; Engelbrecht-Wiggans, Haruvy, and Katok 2007; Millet et al. 2004) and relational (Jap 2003, 2007).

By their very nature, procurement auctions involve repeated interaction, long-term dynamics, and considerable economic stakes. In addition, bidder behaviors in these auctions might be influenced by a host of issues that are external to the auction, such as gaining a strategic position with the buyer or accounting for the bidder’s own economic concerns (Engelbrecht-Wiggans, Haruvy, and Katok 2007). Given these considerations, procurement auctions cannot and should not be viewed as stand-alone auctions the way consumer auctions have often been analyzed. This article provides insight into one aspect of these dynamics—namely, relationships. We consider how ongoing relationships (and the potential for relationships) ex ante affect bidding behaviors in the auction event and how those individual bidding behaviors, along with the specific auction event characteristics, affect the relationship (and its potential) ex post. Specifically, we consider how the bidders

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© 2008, American Marketing Association
ISSN: 0022-2437 (print), 1547-7193 (electronic)
in an industrial auction "trade off" potential economic and noneconomic investments in the relationship against their bid prices. Thus, we generate insights into the crafting of successful interorganizational exchange. Although some research has considered bidding behavior in procurement auctions (the most notable being the winner's curse), there has been little study of how the behavior of individual bidders might influence and be influenced by factors external to the auction itself.

Our innovation is in jointly examining industrial procurement auction behaviors with pre- and postauction characteristics. To date, most work has focused on (1) postauction outcomes, such as final prices and overall savings (Millet et al. 2004), and relational effects (Jap 2003, 2007) as a function of auction design and (2) psychological explanations for bidding (for an overview, see Kagel 1995).1 We go beyond these research streams to provide insight into how complex relationships (and the potential for these relationships) outside the auction interact with the bidding demands and design factors of technology-based auctions.

We use data from 60 participants in 12 industrial online reverse auction events, employing point-by-point bid data and confidential reports of the state of the buyer-supplier relationship before and after the auction. Because the data involve a single event for each bidder, the dynamics and economic considerations not captured by the relationship variable we consider will translate into substantial heterogeneity in bidding preferences; we capture this heterogeneity using random-effects panel methods. The data we use are extremely difficult to obtain and are imperfect, but they offer unique insights that may spur additional interest and research on this critical topic. We consider various forms of aggressive bidding behavior, including the total number of bids a supplier makes, the rate at which these bids are made, and the degree of price concessions offered. Finally, we account for auction characteristics, such as the number of bidders that participate in the auctions, the number of bids that are made over the course of the auction, and the duration of the auction. The results provide strong evidence that interorganizational relationships and auction design exert systematic effects that can affect both individual bidding behavior and relationship outcomes.

We organize the rest of this article as follows: In the next section, we review the relevant literature and develop several hypotheses. We then describe the research setting and specific empirical analysis. Finally, we discuss the key results, limitations, and managerial implications and provide directions for further research.

**CONCEPTUALIZATION**

In this section, we briefly describe the general online reverse auction process and related research and then develop our hypotheses. We also describe several auction format variables, such as incumbency, competition, and event duration.

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1Recently, more aspects of behavior have been examined, including learning (Neugebauer and Selten 2006), impulse balance (Ockenfels and Selten 2005), hierarchical thinking (Gneezy 2005), spiteful bidding (Morgan, Seltzer, and Reis 2003), and regret (Engelbrecht-Wiggans and Katok 2006b).

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2Prequalification procedures might include site visits, research, extensive surveys on capabilities and manufacturing processes, or other buyer designed and quality inspection processes.

3However, note that though the auction itself may not determine the winner, a buyer-determined auction nevertheless plays a critical role in the buyer's price discovery efforts and supplier choice. Instead of each bidder submitting a price, each bidder could be viewed as submitting a score involving both a price and a nonprice attribute. The winner is not the lowest bidder, but the one that presumably scores the highest on both price and nonprice characteristics. To this end, the theoretical treatment of this price discovery mechanism is equivalent in all respects to that of auctions in which the lowest bidder wins.

4Anwar, McMillan, and Zheng (2006) examine cross-bidding behavior across competing eBay auctions and find that such behavior is common, whereas Engelbrecht-Wiggans and Katok (2006a) find that auctions followed by negotiations with an incumbent can improve buyer surplus.
The behavioral literature has focused on several forms of bidding behavior, which we incorporate and examine here: the total number of bids submitted by an individual supplier, the rate at which these bids are submitted, and the price concessions offered by the bids. The number of bids, including multiple bids submitted over the course of the auction, is a common measure of bidding behavior (Ariely and Simonson 2003; Wilcox 2000) that may reflect the supplier’s commitment to winning and responsiveness to other bids.

The rate at which the bids are submitted provides a complementary measure of aggressiveness, underscoring the speed of the supplier’s response. Speed of response in auctions has been studied by Häubl and Popkowski-Leszczyc (2006), Katok and Kwasnica (2002), and Tuunanen, Van Heck, and Koppius (2001). The rate is defined as the total number of bids submitted divided by the auction duration. As such, it can be viewed as a rescaling or normalization of the first measure.

Finally, the level of price concessions (i.e., the difference between the bidder’s first and last bids) offered (Ariely and Simonson 2003; Heyman, Orhun, and Ariely 2004; Ku, Malhotra, and Murnighan 2005) provides insight into the degree of commitment toward winning or fending off competitors. Although we acknowledge that there may be more alternative measures to consider, we use these measures as a first step in providing insight into the individual-level bidding processes and behaviors that may occur in industrial procurement auctions.

The Relationship and Bidding Behavior

The large body of research on interorganizational relationships management in marketing suggests that such relationships systematically affect how the parties interact with each other and into the future (Dwyer, Schurr, and Oh 1987; Ring and Van de Ven 1994). Relationships also allow for the creation of key benefits, such as trust, commitment, collaboration, and higher economic returns. As such, we expect that suppliers account for this asset by trading off these relationship benefits against their bid price; that is, higher prices are justified when relationships (or their potential) are positive. Although a relationship can comprise a complex interface of multiple factors, for simplicity and the sake of initial research in this topic, we consider two aspects that speak to key economic and noneconomic aspects: willingness to make specific investments on the part of the buyer and willingness to develop or maintain a long-term, functional relationship.

Willingness to make specific investments. In many buyer-supplier relationships, one or both parties may make specific economic investments to increase the effectiveness and efficiency of one or both parties (Heide 1994; Lusch and Brown 1996; Noordewier, John, and Nevin 1990). These nonfungible investments might represent tangible (e.g., plant equipment, tooling, design systems) or intangible (e.g., human resources, training) adaptations and represent a credible signal of a supplier’s commitment to the buyer (Anderson and Weitz 1992). By taking on significant economic risk, suppliers lose the incentive to act opportunistically (Williamson 1975) and enable the creation of additional value (Jap 1999; Rokkan, Heide, and Watne 2003). As such, a supplier’s willingness to make such investments might supplement or substitute for price, leading the supplier to bid less aggressively in the auction. If there is an implicit trade-off between a supplier’s economic investments and its bid price, the reverse should also hold true. That is, suppliers that are less willing to make specific investments in the relationship ex ante might instead apply the economic resources toward price concessions. Thus, less willingness to make relationship-specific investments could also lead to higher (or more active) bidding aggression.

H1: Suppliers that are willing to make specific investments bid less aggressively.

There are plausible counterarguments to this directional hypothesis. One-sided investments create a holdup risk for the supplier that must be strategically managed. This might mean that suppliers are more willing to give up price in the short run (i.e., bid more aggressively) in lieu of making specific investments. In addition, it is possible that suppliers will come to experience a sense of ownership over the purchase contract to the point that they discount the value of their willingness to make specific investments, leading them to bid aggressively. Evidence of this can be found in consumer auctions (Heyman, Orhun, and Ariely 2004).

Relationship propensity. Along with economic tendencies, suppliers can approach interorganizational exchanges with intentions and expectations of developing a long-term relationship with the buyer; this is a key strategic decision that requires time, effort, and energy. We index this propensity for incumbents through satisfaction with their ongoing relationship with the buyer and for new suppliers through the concept of solidarity, a critical precursor to healthy relationships. The supplier’s satisfaction with the relationship is a key performance outcome, reflecting a positive affective assessment of all aspects of a working relationship to date, and is one of the most studied outcome variables in interorganizational management research (for reviews, see Gaski 1984; Geyskens, Sieenkamp, and Kumar 1999; see also Ruekert and Churchill 1984); it is the best indicator of an incumbent supplier’s propensity for future relationships. New suppliers can only possess a propensity for, or readiness to develop, an ongoing relationship. We index this tendency for new suppliers through the concept of solidarity, defined as “a bilateral expectation that a high value is placed on the relationship” (Heide and John 1992, p. 36). Solidarity is a widely used concept in the sociological literature on interpersonal and group relationships, reflecting the extent and intensity of affective bonds (Cramer and Champion 1975). Suppliers that are willing to develop such bonds are more likely to solve problems jointly in an integrative manner, share information, and make efforts to improve the relationship (Lusch and Brown 1996).

Collectively, we anticipate that suppliers with a propensity for developing a relationship with the buyer (whether they are new suppliers that are willing to develop a beneficial relationship or incumbent suppliers that are satisfied with their ongoing relationship) may bid differently from suppliers without such tendencies. For suppliers that desire a long-term relationship with the buyer, the potential for greater value is created by moving beyond the basic transaction of goods for money. As a result, price becomes only one aspect of the total exchange. Another way of stating
Bidding Behavior in Industrial Online Reverse Auctions

this effect is that suppliers may substitute or add in noneconomic benefits from their experience with the buyer as part of their pricing strategy, resulting in higher prices. The converse should also hold true; that is, if suppliers trade off their willingness to develop a long-term relationship with their pricing strategy, suppliers with low relationship propensity might instead substitute such efforts against their bid price (i.e., bidding more aggressively), thus enabling them to compete against suppliers that are higher in relationship propensity (and less price aggressive).

H2: Suppliers that are high in relationship propensity bid less aggressively.

A downside to the development of close relationships is that the buyer may learn critical competencies or cost information from the supplier that could reduce the supplier's bargaining position and lead to expectations of buyer opportunism (Srivastava, Chakravarti, and Rapoport 2000). In consumer settings, Reinartz and Kumar (2000) show that long-term customer relationships do not always translate into the most profitable relationships. In this case, suppliers would need to give up more price concessions and bid aggressively.

Bidding Behavior and Postauction Relationship Outcomes

Research has shown that the auction characteristics, such as the type of auction format, the number of bidders, and the economic stakes, can systematically affect the ex post buyer–supplier relationship (Jap 2003, 2007). We add the possibility that individual bidding behavior also affects the buyer–supplier relationship. Specifically, suppliers that desire a long-term relationship with the buyer may view the focus on price in the auction as a source of opportunism and haggling that is hostile to their exchange. This is because in long-term relationships, participants tend to move away from price as a governing mechanism and may instead rely on "average cost pricing," such that they abandon a constant price focus and supplement or substitute other noneconomic benefits and information, resulting in less variability in transaction prices as a function of the buyer’s activity levels (Bradburd and Caves 1987). If suppliers feel forced to bid aggressively in the auction, they may believe that buyers are using the auctions to strong-arm additional price concessions from them. In online reverse auctions, these perceptions persist, even though buyers are not at all intending or attempting to act opportunistically (Jap 2003). Thus, we would expect that the more aggressive the suppliers' bidding behavior in the auction, the greater is the detriment posed to their relationship (i.e., the lower is the propensity for a long-term relationship). Similarly, suppliers that do not bid aggressively may not feel strong-armed into giving up price concessions and may be more willing to develop a long-term exchange relationship with the buyer (because there is no threat of opportunism, but rather the potential to grow the business together).

H3: Suppliers that bid aggressively are likely to have lower relationship propensity after the auction.

The impact of aggressive bidding on the supplier's willingness to make specific investments after the auction is more difficult to predict. Assuming that the impact of preauction willingness to make investments is held constant, in general, a supplier that bids aggressively will have fewer resources to make specific investments. In addition, the need to give up substantial price concessions can have a demoralizing impact on bidders, which might dampen motivation to make further costly specific investments on the buyer's behalf. Furthermore, specific investments create a nontrivial holdup potential.

Conversely, aggressive bidding might lead the supplier to realize the need for specific investments, either to differentiate its offering or to reach cost curves that competitors have attained. This is the general result that Jap (2003) finds. She observed incumbent suppliers in full price visibility auctions matching the willingness of new suppliers to make specific investments; however, she could not attribute this increased willingness to any specific behavior or incidences in the auction, which is our goal here. It is possible that the mere observation of the drop in competitive pricing was sufficient to motivate suppliers’ willingness to make specific investments; suppliers did not necessarily need to give up the price concessions to come to the same conclusion. Thus, we propose the following hypothesis:

H4: Suppliers’ aggressive bidding behavior is related to their willingness to make specific investments after the auction (controlling for suppliers’ preauction willingness to make specific investments).

Auction Format Variables

Our interest is primarily in how bidding behavior is affected by and affects key interorganizational relationship states and outcomes. However, we also control for various differences across the auctions that might affect both bidding behaviors and relationship states—namely, incumbency, competition, and event duration. Incumbent suppliers possess the current supply contract that is up for bid in the auction. As such, they have the most recent history of exchange with the buyer and a current understanding of the buyer’s needs and constraints. Competing suppliers may be incumbents or completely new. We account for the level of competition through the number of bidders (Ariely and Simonson 1993; Ku, Malhotra, and Murnighan 2005)—not including the focal supplier—and the total number of bids made by these bidders (Ariely and Simonson 1993; Heyman, Orhun, and Ariely 2004). The more bidders and bids in an event, the higher is the level of competitive arousal. Alternatively, as the number of bidders increases, bidders may become more conservative because the potential for the winner's curse grows as the number of bidders does (Hong and Shun [2002] show this in a procurement setting). Finally, the duration of the event has been shown to affect bidding behavior in auctions systematically (Heyman, Orhun, and Ariely 2004; Ku, Malhotra, and Murnighan 2005). Specifically, as the duration increases, bidders tend to develop a sense of ownership or bonding with the item, causing them to bid more aggressively to avoid losing the item (Heyman, Orhun, and Ariely 2004).

\(^{5}\)This might be due to the compressed nature of bidding and the aggregate price drop (Stein, Hawking, and Wyld 2003).
METHODOLOGY

Procedure

We examine the hypotheses using online reverse auction events held in the supply bases of two Fortune 50 firms in the automotive and high-tech industries. Each firm was offered customized analyses and a summary report in return for its participation. Each firm identified 6 auction events (for a total of 12 events), for which they provided point-by-point bid data and allowed us to obtain confidential survey reports from suppliers before and after the auction. However, the firms did not allow us to intervene in these events, such as to create untreated control groups or matched pairs of events or to interview the participants. Suppliers in the auctions were classified as incumbents and nonincumbents to distinguish those that were the current suppliers. All the auctions were full-price-visibility buyer-determined events, and bidders did not know the exact identity of their competitors.

The auctions covered various product categories ranging from hoses, pulleys, subassemblies to cables, metal and plastic parts, and electronic connectors, to name just a few. The products were all materials used directly in the manufacturing processes, and the combined contract value of the 12 auctions was approximately $125.5 million. The average value of the purchase contract was $10.5 million (SD = $12.5 million, range = $1 million–$47.7 million), and the mean number of lots was 4.2 (SD = 2.8, range = 1–10). Of the participants in these events, 69% were incumbent suppliers. All the products differed in their nonprice characteristics, so that supplier relationships could play a role in the negotiation process.

Respondents were typically senior executives, vice presidents, and even owners of the supply company who handled large customer accounts with authority to determine major investment decisions and make price concessions. An invitation e-mail was sent one week before the event, specifying that the respondent should be knowledgeable about the firm’s specific relationship with the buyer and should be someone who would participate in the upcoming auction. Across the events, 130 suppliers were invited to complete the survey, and 58 participated, resulting in a response rate of 45%. An examination of the data from early versus late respondents fails to reject the null hypothesis of no difference among the responses (Armstrong and Overton 1977).

We also examined whether there were differences in the bidding behavior of respondents and nonrespondents. There were no significant differences in the number of bids (p < .36), bidding rate (p < .41), price concessions (p < .84), or incumbency status (p < .64). Collectively, these results suggest that there were no notable differences between respondents who responded to the survey and those who did not.

Because the relationship measures rely heavily on the respondents’ perceptions, we included specific and global measures of their knowledge of the relationship and competency. The global measure was the respondents’ tenure with the firm. The respondents averaged 3.3 years (SD = 1.1 years, range = .7 years–8 years) of experience in their area and had been with their firms for 7.0 years (SD = 3.0, range = .7 years–18 years) on average. We assessed the respondents’ knowledge of the relationship with the buyer with questions at the conclusion of the survey. The respondents were asked, “How knowledgeable are you about the following aspects?” Then, items such as “Your firm’s willingness to work with the buyer firm,” “The state of your firm’s relationship with the buyer firm,” and “Your firm’s willingness to invest in a customer” were listed. Responses varied along a seven-point rating scale (1 = “not very knowledgeable,” and 7 = “very knowledgeable”), with a mean of 6.3 (SD = .55, range = 4.5–7). Collectively, these measures suggest that the respondents were qualified key informants, knowledgeable about their relationship with the buyer, and competent in their roles to be reporting on the state of the buyer-supplier relationship.

The invitation directed suppliers to the survey on a university Web site, guaranteed individual anonymity to the buyer, and reassured suppliers that the buyer would not have access to individual responses. The survey directed the supplier to complete all items in reference to the specific buying organization. The posttest survey was administered within a week after the event; at this time, buyers had not begun any postauction negotiations, and suppliers were not yet informed whether they had won the event, implying that the posttest scores are a direct function of the auction process and are uncontaminated by the auction outcome or buyer interventions. Throughout the data collection, we monitored the buyer’s activities to ensure that no major events or initiatives (e.g., retroactive charge backs) occurred to disrupt or alter supplier perceptions and attitudes.

Measurement

All the items used to measure the interorganizational relationship constructs appear in the Appendix. Multi-item scales (1 = “strongly disagree,” and 7 = “strongly agree”) measure the various relationship facets; we adapted all the scales from prior research. We adapted the three items for satisfaction with the relationship from the work of Ruekert and Churchill (1984), and we adapted the three items for solidarity from the work of Heide and John (1992) and Dwyer and Oh (1988). We adapted the seven scale items for willingness to make specific investments from the work of Jap (2003). Table 1 displays the construct means, correlations, and reliabilities for the latent factors.

Analysis

Factor analysis. We estimated a confirmatory factor model of the three first-order latent constructs, including the observable indicators, measurement errors, and intercorrelations between the constructs, using full-information maximum likelihood techniques in LISREL 8.54 (Jöreskog and Sörbom 2003). The overall chi-square for the model is 155.83 (d.f. = 62, p < .00) with a comparative fit index and incremental fit index of .88, a Tucker–Lewis index of .86, and a root mean square error of approximation of .15.7

6Incumbency data for nonrespondents were available for 6 of the 12 events. However, bidding behavior data for nonrespondents were available for all events.

7Although minimum comparative fit index, incremental fit index, and Tucker–Lewis index values of .9 are typically recommended, in sample sizes of fewer than 200, these indexes are unlikely to achieve this rule-of-thumb benchmark (Bearden, Sharma, and Teel 1982; Marsh, Balla, and Hau 1996; Marsh, Balla, and McDonald 1988).
The measure of relationship propensity comprises average responses to relationship satisfaction items and solidarity items. To validate the use of this measure further, we considered its relationship to a multi-item measure of opportunism suspicions (Jap 2003). Presumably, the more relationship propensity a supplier has toward the buyer, the fewer suspicions of opportunism it should have about the buyer. The correlation between these two measures is significant and negative (-.36, \( p < .01 \)), providing some face validity support of our measure.

Regression analysis. We ran two sets of regressions. The first set examined the impact of preauction relationships on bidder aggressiveness in a given auction. The second set examined the effect of auction characteristics, including bidding aggressiveness, on the postauction relationship. We considered alternative specifications, such as the addition of a supplier covariate (i.e., supplier dependence on the buyer) and interaction terms (i.e., among bidder behaviors, incumbency, relationship states, and auction characteristics), but these effects were mostly nonsignificant and did not change the observed pattern of results, which we report subsequently.

In the first set of regressions (see Table 2), we examined the effect of preauction relationships on bidding behavior in the auction. The unit of analysis in this set of regressions is bidder behavior in each individual lot. The total number of observations is 132, with 44 distinct individual bidders (this is panel data estimation with an unbalanced panel). That is, if a bidder participated in three different auctions, we would count this as three observations and account for the correlation in the error structure using random-effects modeling, such that each individual bidder has its own intercept, which comes from a distribution with a mean of zero and a standard deviation to be estimated. Thus, the relevant regression takes the following form:

\[
    y_i = \beta' x_i + \varepsilon_i + \eta_i
\]

where \( y_i \) is the observed dependent measure for the \( i \)th observation, \( x_i \) is the vector of explanatory variables, and \( \beta \) is the vector of coefficients to be estimated. There are two error terms, \( \varepsilon_i \) and \( \eta_i \). The first error term, \( \varepsilon_i \), is the traditional error term unique to each observation. The \( \eta_i \) error term represents the extent to which the intercept of the \( i \)th bidding firm differs from the overall intercept. Each error term is assumed to be normally distributed with a variance to be estimated.

The estimation is done with a two-step generalized least squares approach. In the first step, we estimate the variance components using consistent estimators—the within- and between-group residuals, respectively—to estimate \( \sigma_w \) and \( \sigma_b \). In the second step, we substitute these estimates into the variance–covariance matrix in the generalized least squares to obtain estimates (for more detail, see Hsiao 1995, pp. 34–38).

The dependent variable in this set of regressions is bidder aggressiveness. As a measure of bidder aggressiveness, we investigated three alternative forms: (1) the number of bids entered by the supplier, (2) bidding rate (the number of bids the supplier entered divided by duration), and (3) price concession (the price drop by the supplier from its first to its last bid). These three dependent variables are highly correlated, supporting the claim that they likely measure the same construct.\(^8\) Two explanatory variables are the preauction relationship variables of relationship satisfaction and willingness to make investments. Other explanatory

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\(^8\)The correlation between bidding rate and concessions is .67. The correlations between bidding rate and supplier bids and between supplier bids and concessions are both .76.

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### Table 1

**VARIABLE MEANS AND CORRELATIONS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
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<td><strong>Preauction Relationship States</strong></td>
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<tr>
<td>1. Relationship propensity</td>
<td>5.46</td>
<td>1.17</td>
<td>2</td>
<td>7</td>
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<td>2. Willingness to make specific investments</td>
<td>5.90</td>
<td>.91</td>
<td>3</td>
<td>7</td>
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<td><strong>Postauction Relationship States</strong></td>
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<td>3. Relationship propensity</td>
<td>5.02</td>
<td>1.37</td>
<td>1</td>
<td>7</td>
<td>.61</td>
<td>.18</td>
<td>1.0</td>
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<td>4. Willingness to make specific investments</td>
<td>5.61</td>
<td>1.02</td>
<td>1</td>
<td>7</td>
<td>-.13</td>
<td>.09</td>
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<td><strong>Bidding Behavior</strong></td>
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<td>5. Supplier's total bids</td>
<td>9.27</td>
<td>12.86</td>
<td>0</td>
<td>54</td>
<td>.12</td>
<td>-.20</td>
<td>.06</td>
<td>.04</td>
<td>1.0</td>
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<tr>
<td>6. Bidding rate</td>
<td>.15</td>
<td>.20</td>
<td>0</td>
<td>.74</td>
<td>.05</td>
<td>-.24</td>
<td>-.10</td>
<td>-.10</td>
<td>.77</td>
<td>1.0</td>
<td></td>
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<td>7. Price concessions</td>
<td>.15</td>
<td>.17</td>
<td>0</td>
<td>.58</td>
<td>.08</td>
<td>-.41</td>
<td>-.08</td>
<td>-.05</td>
<td>.76</td>
<td>.56</td>
<td>1.0</td>
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<tr>
<td><strong>Auction Characteristics</strong></td>
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<tr>
<td>8. Number of bidders</td>
<td>6.53</td>
<td>2.44</td>
<td>2</td>
<td>11</td>
<td>.02</td>
<td>.36</td>
<td>.02</td>
<td>.26</td>
<td>-.10</td>
<td>-.24</td>
<td>-.18</td>
<td>1.0</td>
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<td>9. Total number of bids by other suppliers</td>
<td>42.25</td>
<td>31.20</td>
<td>0</td>
<td>179</td>
<td>.05</td>
<td>.19</td>
<td>.05</td>
<td>.18</td>
<td>.47</td>
<td>.21</td>
<td>.43</td>
<td>.27</td>
<td>1.0</td>
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<tr>
<td>10. Event duration</td>
<td>63.35</td>
<td>38.52</td>
<td>6</td>
<td>213</td>
<td>-.04</td>
<td>.02</td>
<td>.16</td>
<td>.20</td>
<td>.43</td>
<td>-.07</td>
<td>.32</td>
<td>.09</td>
<td>.68</td>
<td>1.0</td>
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<td><strong>Supplier Status</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Incumbent</td>
<td>.69</td>
<td>.47</td>
<td>0</td>
<td>1</td>
<td>-.68</td>
<td>.12</td>
<td>-.54</td>
<td>.23</td>
<td>-.13</td>
<td>-.28</td>
<td>-.08</td>
<td>.10</td>
<td>.23</td>
<td>.24</td>
<td>1.0</td>
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</tbody>
</table>

Notes: Correlations greater than .26 are significant at \( p < .05 \).
variables are the number of bidders, the number of bids by others (excluding own bids to avoid endogeneity), an indicator variable for incumbency, and event duration in minutes. Because the dependent variables are highly correlated and the predictors for each are identical, a simultaneous estimation is not possible.

The second set of regressions (Table 3) examines the impact of the auction process on the postauction relationships. Because relationships were elicited after all auctions were completed, the unit of observation is the individual bidder's perception over all product lots. That is, whereas the unit of analysis in the first set of regressions is bidder behavior in each individual lot (accounting for the panel structure with random effects), here the data are purely cross-sectional, with the bidder as the unit of observation (n = 58). Accordingly, the values of the explanatory variables were pooled over all auctions in which a bidder actively participated.

There were two dependent variables: the postauction relationship propensity and willingness to make investments. The explanatory variables included the preauction state of the dependent variable, the number of bidders participating in the auction, the number of bids by other suppliers, an indicator variable for incumbent, and event duration. The last explanatory variable was bidder aggressiveness. We investigated the same three alternative measures as in the first set of regressions, one at a time, because they are highly correlated: the number of bids the supplier entered, bidding rate, and price concession. Given the nature of the linkages between the dependent variables, error terms corresponding to some of the equations could be correlated. Therefore, we simultaneously estimated each pair of regressions using a seemingly unrelated regression, which uses the correlation in errors across equations to yield more efficient regression estimates (Johnston and DiNardo 1997).

Results. The parameter estimates for the impact of prior relationships on bidding behavior appear in Table 2. Supplier willingness to make investments before the auction is negatively related to the supplier's total bids in the auction (−.203, p < .02), bidding rate (−.134, p < .05), and price concessions (−.256, p < .00), providing support for H1. Relationship propensity before the auction is marginally related to the supplier's total bids (−1.75, p < .10) and the bidding rate (−.187, p < .06) but not price concessions (−.098, p < .23). Thus, although the results are directionally correct, H2 is only partially supported. Perhaps with a larger sample size or more auction events, these estimates would approach a higher level of significance.

In addition, the results suggest that incumbency has a significant, negative impact on the bidding rate (−.385, p < .01) and total number of bids (−.415, p < .01) but not on their price concessions (−.205, p < .19). The number of bidders in the auction also has a significant, negative impact on all three forms of bidding behavior: the supplier's total bids (−1.30, p < .03), bidding rate (−.206, p < .01), and price concessions (−.180 p < .01). The total number of bids in the auction by other suppliers also appears to raise bidding aggressiveness, significantly affecting the supplier's total bids (.322, p < .01), bidding rate (.438, p < .01), and price concessions (.315, p < .01). Finally, the longer the duration of the event, the lower is the rate of bidding (−.465, p < .01).

The parameter estimates for the impact of bidding behavior on postauction relationship satisfaction and willingness to make investments appear in Table 3. The supplier's bidding rate (−.261, p < .02), price concessions (−.266, p < .01), and total number of bids (−.186, p < .07) have a significant impact on relationship propensity. To corroborate this further, we find that the course of the auction, suppliers were significantly (Cochran t-test = 2.68, p < .01) more likely to agree with the statement, "This process does
not give a supplier a fair opportunity to bid on business” (1 = “strongly disagree,” and 7 = “strongly agree”) before the auction (4.31) than after the auction (3.57), suggesting that the suppliers viewed the auction process as unfair. Together, the results strongly support H₃.

The impact of bidding behavior on supplier willingness to make specific investments is consistently positive but marginally significant only for price concessions (.268, p < .09). Thus, H₄ is partially supported.

Combined, the results of H₁ and H₂ provide insight into a potentially cyclical pattern over time. The result of H₁ shows that higher levels of willingness to make investments lead to lower levels of bidding aggressiveness, whereas the result of H₄ suggests that higher levels of bidding aggressiveness lead to higher levels of willingness to invest, after we control for preauction willingness to invest. In a repeated auction context, we might expect this type of pattern (assuming that marginal productivity of specific investments decreases over time) to converge to a long-term equilibrium or state marked by incrementally smaller changes in supplier willingness to make investments as the supplier dynamically adjusts its investment and bidding toward optimal levels.

In addition, the results suggest that incumbents experience a significant, negative drop in relationship propensity (−.372, p < .01; −.458, p < .01; and −.378, p < .01). To corroborate this further, we find that incumbents’ agreement with the statement “This auction process reduces the likeli-

### Table 3

**RELATIONSHIP REGRESSION RESULTS**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Postauction Relationship</th>
<th>Willingness to Make Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bidding Behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier's total bids</td>
<td>−.186 (.125)*</td>
<td>.183 (.148)</td>
</tr>
<tr>
<td><strong>Supplier Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incumbent</td>
<td>−.372 (.152)***</td>
<td>.181 (.125)</td>
</tr>
<tr>
<td><strong>Auction Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of bidders</td>
<td>−.035 (.108)</td>
<td>.123 (.128)</td>
</tr>
<tr>
<td>Total number of bids by others suppliers</td>
<td>−.047 (.158)</td>
<td>−.207 (.181)</td>
</tr>
<tr>
<td>Event duration</td>
<td>.379 (.141)***</td>
<td>.202 (.163)</td>
</tr>
<tr>
<td><strong>Relationship Before Auction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relationship propensity</td>
<td>.396 (.142)***</td>
<td>—</td>
</tr>
<tr>
<td>Willingness to make investments</td>
<td>—</td>
<td>.477 (.129)***</td>
</tr>
<tr>
<td>System R²</td>
<td>.421</td>
<td></td>
</tr>
<tr>
<td><strong>Bidding Behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bidding rate</td>
<td>−.261 (.127)**</td>
<td>.169 (.146)</td>
</tr>
<tr>
<td><strong>Supplier Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incumbent</td>
<td>−.458 (.160)***</td>
<td>.184 (.127)</td>
</tr>
<tr>
<td><strong>Auction Characteristics</strong></td>
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<td></td>
</tr>
<tr>
<td>Number of bidders</td>
<td>−.083 (.111)</td>
<td>.144 (.133)</td>
</tr>
<tr>
<td>Total number of bids by others suppliers</td>
<td>.058 (.171)</td>
<td>−.236 (.195)</td>
</tr>
<tr>
<td>Event duration</td>
<td>.231 (.146)</td>
<td>.311 (.174)*</td>
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<tr>
<td><strong>Relationship Before Auction</strong></td>
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<td></td>
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<tr>
<td>Relationship propensity</td>
<td>.319 (.147)***</td>
<td>—</td>
</tr>
<tr>
<td>Willingness to make investments</td>
<td>—</td>
<td>.477 (.130)***</td>
</tr>
<tr>
<td>System R²</td>
<td>.433</td>
<td></td>
</tr>
<tr>
<td><strong>Bidding Behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price concession</td>
<td>−.266 (.118)***</td>
<td>.268 (.157)*</td>
</tr>
<tr>
<td><strong>Supplier Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incumbent</td>
<td>−.378 (.145)***</td>
<td>.174 (.120)</td>
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<tr>
<td><strong>Auction Characteristics</strong></td>
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<td></td>
</tr>
<tr>
<td>Number of bidders</td>
<td>−.076 (.108)</td>
<td>.139 (.127)</td>
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<td>Total number of bids by others suppliers</td>
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<td>−.288 (.191)</td>
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<td>Event duration</td>
<td>.346 (.135)***</td>
<td>.250 (.158)</td>
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<td><strong>Relationship Before Auction</strong></td>
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<tr>
<td>Relationship propensity</td>
<td>.388 (.138)***</td>
<td>—</td>
</tr>
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<td>Willingness to make investments</td>
<td>—</td>
<td>.565 (.142)***</td>
</tr>
<tr>
<td>System R²</td>
<td>.447</td>
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</table>

*α = .10, **α = .05, ***α = .01.

Notes: All estimates are standardized. Standard deviations appear in parentheses. These are significance levels to a two-sided t-test, except for significance levels for bidding behavior in the “Relationship Propensity” column, which we reported on a one-sided basis because the corresponding hypothesis (H₃) is one-sided.
hood that we will win the business" (1 = “strongly disagree,” and 7 = “strongly agree”) is significantly (Cochran t-test = 2.03, p < .05) higher (3.46) than new suppliers (2.58), suggesting that the incumbents viewed the auction experience as inhibiting their chances of success, and this belief could have affected their desire to develop a long-term relationship with the buyer. Event duration has a positive, significant or marginally significant effect on relationship propensity in two of three cases (.379, p < .01; .231, p < .12; and .346, p < .01) and on willingness to make investments, with bidding rate as an explanatory variable (.311, p < .08). The number of bidders and the total number of bids by others are not significant.

**DISCUSSION**

**Relationship Management Insights**

The results of this study suggest that economic and noneconomic relational factors, whether they are assessments of ongoing relationships or willingness to invest in future relationships, are a systematic part of the bargaining effort, both before and after the online procurement auction. The results suggest that suppliers trade off these relational factors with their pricing strategy (i.e., bidding aggressiveness). Specifically, suppliers that are willing to make specific investments with the buyer before the auction will also submit fewer bids, bid less often, and make fewer price concessions as a result. The results also suggest that the same is true of supplier willingness to develop a long-term relationship with the buyer. Together, these results provide insight into the strategic bidding behavior of suppliers in which they appear to trade off potential economic and relational investments in long-term exchange with short-term pricing concessions. Consistent with this, we also observed that incumbents’ total number of bids is higher and the speed of response to competitive bids is lower than those of new suppliers, suggesting that the value of their history of exchange and idiosyncratic knowledge of the buyer is being traded off with their pricing policies. Collectively, this supports the view of industrial exchange relationships as more than one-shot deals; they are ongoing, systematic exchange structures that can affect behavior over the course of the auction.

The interrelationship between buyer–supplier relationships outside the auction and bidding behavior does not stop there. We also observe that aggressive bidding behavior over the course of the auction can take its toll on relationships after the auction. Specifically, the results indicate that suppliers that rapidly submitted bids or made price concessions have lower propensity for a relationship after the auction, supporting the notion that the auction experience is a negative price-haggling process. Bidders believed that the auction process was unfair and reduced the probability of retaining their business. This negative sentiment was particularly acute for incumbents, suggesting that the auction process soured their satisfaction with the buyer.

Whereas prior research has found evidence of full visibility auctions increasing supplier willingness to make idiosyncratic investments (Jap 2003), we find only marginal support for this effect. It could be that over time, as suppliers gain more experience with the auction format and improve their sense of market pricing, the auction becomes a less effective wake-up call. To this end, note that the auctions in Jap’s (2003) study involved the buyers’ initial introduction of auctions to their supply base, whereas the auctions in the current research occurred in later stages and with experienced buyers and suppliers. Over the long run, a supplier’s willingness to make specific investments in a buyer might be calibrated, as a result of its learning about what the optimum levels of investments should be over several auction experiences. This might explain why Jap (2003) observes a strong effect of postauction willingness to make investments, whereas we observe a weaker effect. Perhaps suppliers are still adjusting their willingness to make investments and have not yet settled into a long-term equilibrium or point of convergence. Further research is needed to investigate this possibility.

**Auction Design Insights**

In addition to these relationship effects, we find several key findings in regard to auction design. First, we find that suppliers bid less aggressively as the number of bidders in an auction increases. Perhaps too many bidders in an auction raise suspicions that there are nonqualified bidders present (Jap 2007). In some product categories, suppliers are well aware of the number of viable competitors that can provide specific products. If the number of suppliers exceeds the known number of viable alternatives, suppliers may refuse to bid aggressively against nonviable suppliers.

Second, bidders appear to be responsive to the number of bids collectively submitted by the competition, increasing their total bids, rate of submission, and price concessions offered. Apparently, this is a more credible signal of competitive threat than the number of bidders. It might also be that this is the element of competitive intensity that mostly motivates industrial bidders and adds to auction fever—the emotionally charged and frantic behavior that can result in overbidding (Ku, Malhotra, and Murmighan 2005), a sense of “quasi endowment” of the purchase contract (Heyman, Orhun, and Ariely 2004), and aversion to losing the auction. To this end, bidding aggressiveness in response to the total number of bids by others may represent a psychological escalation of commitment (Staw 1976).

Finally, the length of the auction event represents a trade-off between competitive bidding activity and relationship states. As the event duration increases, suppliers tend to slow down their response to competitive bids, which could affect overall price savings and the level of competitive arousal. Conversely, longer auction events are gentler on the relationship, increasing suppliers’ propensity for a relationship with the buyer and willingness to make specific investments on the buyer’s behalf.

**Implications for Management**

This research has several implications for management. In particular, it underscores the importance of interorganizational relationships and their associated trade-offs with auction design and price in online procurement activities. To this end, we view recent attempts to quantify relationships as an important stepping stone. For example, consider Procter & Gamble’s efforts to develop an expressive language of its constraints and preferences, including rich
forms of capabilities and efficiencies, which have resulted in a 9.6% savings on more than $3 billion in sourcing commitments over a two-and-a-half-year period (Sandholm et al. 2006).

The results also give buyers insight into how suppliers view aggressive bidding in terms of their relationship with the buyer. Specifically, buyers should recognize that suppliers trade off their intangible value (e.g., their willingness to make specific investments) against their price concessions. Thus, high bids do not necessarily mean that suppliers are not bidding aggressively; the “total value” of suppliers is more than just price. This total-value perspective of prices and relationships has implications after the auction. The results suggest that suppliers that feel forced into making price concessions in the auction will also reduce their willingness to engage in and develop the relationship more deeply with the buyer. As the exchange loses the “shadow of the future” and becomes more transaction and price focused, suppliers are motivated to actively seek alternative buyers, retaliate, or act opportunistically against the buyer in the short run (Dal Bó 2005). An approach that buyers can use to preserve relationship propensity after the auction is to lengthen the auction duration, though this might put some level of price competition at risk.

Limitations and Directions for Further Research

We could have considered many more antecedents and consequences of auction bidding behavior, and we encourage researchers to explore these possibilities. The data are limited in that point-by-point bid data do not provide insight into each supplier’s sense of how aggressive its behaviors really are. In addition, the data do not include the ultimate auction outcome, which may have a greater impact on the post-auction relationship over time. However, the impact of the auction process itself is more of an unknown effect, and this is why we focused on it here. Ideally, we would have liked to exert more control, specifically, to create control groups of comparable suppliers or to assign suppliers to events randomly, but this was well beyond the limits of what the host firms would allow.

Although this research attempted to stimulate additional interest in the relationship–technology interface, there are many stones yet unturned. In particular, further research is needed on the bidding behavior and strategies that suppliers use in these auctions. In this research, we considered aggregate forms of bidding behavior, but more work is needed that would illuminate the specific dynamic strategies that suppliers use in buyer-determined auctions, in which the need to be the lowest bidder is not necessarily a winning strategy.

Further research might also examine aggressive bidding behavior in terms of the bidder’s actual “bottom lines.” This is the real benchmark for whether a bid is aggressive. In addition, research should account for the actual auction outcome—whether the supplier won or lost the auction—and the impact on interorganizational relationships in the long run. The cumulative effect of many online reverse auction experiences on the state of interorganizational relationships over time is still unknown.

This research focused on supplier perceptions and intentions before and after a single event and bidding behavior during that event. However, the interaction between suppliers and buyers is typically repeated, and a data set of a series of auctions might shed light on the patterns of and relationships between investment and bidding aggressiveness over auction events. In particular, our results suggest that higher investment intention before the auction leads to lower bidding aggressiveness, but lower bidding aggressiveness leads to lower investment intentions after the auction. Thus, patterns of oscillation in investment levels and bidding aggressiveness may result over auctions, and it would be of interest to identify such patterns more clearly in data sets that include multiple auction events over time.

APPENDIX: SURVEY ITEMS

Satisfaction with the Relationship (Cronbach’s α = .76)

This section assesses your firm’s relationship with the buyer firm. In the items that follow, “They” refers to the buyer firm, and “We,” “Our,” and “Us” refer to your firm. Please indicate the extent to which you agree or disagree with the following statements. (1 = “strongly disagree,” and 7 = “strongly agree”)

- Our relationship with them has more than fulfilled our expectations.
- We are satisfied with the outcomes of our relationship.
- Our relationship with them has been a successful one.

Willingness to Develop Solidarity (Cronbach’s α = .57)

How willing is your firm to do the following for the buyer firm? (1 = “very unwilling,” and 7 = “very willing”)

- View problems that arise in the course of this relationship as joint rather than individual responsibilities.
- Be committed to improvements that may benefit the relationship as a whole, and not only the individual firms.
- Not mind owing each other favors.

Willingness to Provide Dedicated Investments (Cronbach’s α = .93)

In working with the buyer firm, your firm may have opportunity to make investments in time, energy, and/or money specifically to accommodate them. These investments would be lost if your firm switched to another customer. (1 = “strongly disagree,” and 7 = “strongly agree”)

Just for the buyer firm, we would be willing to provide dedicated ...

- Support personnel
- Technology investments
- Design systems (i.e., computer-aided design)
- Training for buyers
- Production procedures
- Capital equipment and tools
- Plant capacity

REFERENCES


Bidding Behavior in Industrial Online Reverse Auctions


