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Keywords: Arbitration, Dispute Resolution, Experiments

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Strategic Bidding and Investments in Final Offer Arbitration: Theory and Experimental Evidence

Given the sizeable savings, many disputes are resolved via arbitration. Numerous studies have considered the strategic incentives of various forms of arbitration, most notably Final Offer Arbitration (FOA). While previous work focused exclusively on optimal offers, in reality disputants make a series of perhaps interrelated choices. This paper considers FOA disputants making an additional investment decision regarding their case. We consider three cases distinguished by the sequence and observability of choices. The theoretical results indicate that it is socially optimal for disputants to make publicly observable offers prior to investment decisions. Behavior observed in the lab weakly confirms this conclusion.

1. Introduction

As the costs of litigation continue to rise, arbitration is an increasingly used alternative dispute resolution mechanism. While labor disputes have been the most common type of disagreements to be settled via arbitration mechanisms, the breadth of cases settled by arbitration is rapidly expanding. The benefits of arbitration over litigation include restrictions on discovery and a much more rapid time to reach resolution; both of these benefits may translate into substantial savings relative to standard litigation (Bernstein 1993). For example, Apple Computer saved over $4 million in legal fees in a case with the IRS in addition to preventing the revelation of proprietary information which would have occurred in standard litigation (Fuller, 1993). Moreover, Tax Rule 124 permits any factual issue to be decided via voluntary binding arbitration rather than litigation and the Supreme Court has recently ruled that employers can force their employers to use arbitration as the mechanism to settle labor disputes.

This increasing reliance on arbitration in practice necessitates an understanding of the strategies and incentives that the various forms of arbitration may generate. While researchers have begun to explore arbitration, the focus of this new body of research largely revolves around bidding strategies and settlement rates. While conventional arbitration (CA) mimics civil litigation in form, final offer arbitration (FOA) proposed by Stevens (1966), requires that agents submit a final bid and the arbitrator must choose one of the two; there is no splitting the difference. Farber (1980) analyzed the optimal
bidding strategy for agents facing FOA, and subsequent work examined bidding strategies under asymmetric information and the possibility of renegotiation after the bids have been submitted. (See Farmer and Pecorino, 1998 and 2003) A number of researchers have studied new mechanisms including tri-offer (Ashenfelter, et al., 1992) combined arbitration (Brams and Merrill, 1986), double-offer (Zeng, et al., 1996) and Amended Final Offer (Zeng, 2003). The thrust of this entire body of work has been on understanding the incentives these mechanisms create in making offers and how such incentives translate into settlement rates. Some experimental work has followed this body of theoretical work in an effort to investigate whether the bidding and ultimately the settlement strategies predicted hold up in the laboratory (see Ashenfelter et al 1992, Dickinson, 2004, Pecorino and Van Boening, 2001 and Deck and Farmer, 2005b, Deck, et al. 2005).

What bid to place is but one strategic decision faced by a disputant. In arbitration disputants also make strategic choices as to what legal representation to employ, what evidence to present, what counterarguments to make, etc. However, none of the aforementioned work has addressed the incentive to invest effort in developing and presenting a case. While investment in effort to influence the outcome has been investigated in civil litigation (Farmer and Pecorino, 1999), this issue has been overlooked with respect to arbitration.1 Given that in final offer arbitration the bidding strategy is integral to settlement rates, it is important to question whether the introduction of investment and effort as a strategic variable interacts with the bidding strategies in an important way. As such, it is the goal of this paper to examine both bidding and investment strategies in final offer arbitration.

Moreover, as Farmer and Pecorino (1998) find that renegotiation after bid submission can affect bidding strategies, it is important to ask whether it matters if parties are required to make these investment decisions and present their cases prior to the submission of final offers or afterwards. How will the introduction of this variable alter agents’ decisions to invest and bid? And, if the investment takes place after bids are submitted, does it matter if the bids are revealed or not; and, does knowledge of whether

---

1 To the degree that civil litigation and conventional arbitration are similar, the results of Farmer and Pecorino (1999) are applicable to arbitration.
it will be revealed or not affect the bids themselves? While Farmer and Pecorino investigate the role of renegotiation, in their model there are no investment decisions; their model is one in which asymmetric information may or may not be revealed by the offers and as such, renegotiation after their submission may be meaningful. In this paper, however, there is no asymmetric information, and it is the strategic interaction between investments and bids that we are investigating.

In addition to modeling the theoretical incentives that the interaction of these variables generates, this paper reports the results of laboratory experiments designed to identify the behavioral properties associated with these variables. In the laboratory we are able to control factors that are unobservable in naturally occurring disputes such as the arbitrator’s preferences and perfectly observe decision variables such as investment levels. By comparing theoretical predictions and behavioral regularities a more complete understanding of this situation is developed. The next section introduces the theoretical model. Separate sections detail the experimental design and results and the final section contains a summary discussion.

2. The Model

Suppose that player 2 is to pay player 1 a sum of money $z$ over which the players are in arbitration. Suppose also that the arbitrator will draw a value that represents her preferred value of $z$ from a uniform distribution $U[a, b]$. In addition, players are given the opportunity to make an investment that will shift the distribution from which the arbitrator will choose her value in their favor. This investment can be interpreted as hiring an attorney, spending time building a case etc. Specifically, suppose that player 1 invests $x$ while player 2 invests $y$. Then, the new distribution of $z$ will be $U[a + \gamma(x) - \beta(y), b + \gamma(x) - \beta(y)]$. The marginal cost of each unit of investment is $c$; it is identical across players.

In FOA players must submit a bid to the arbitrator who is then bound to choose one of the two posted bids; there is no splitting the difference. Given this strategic choice, it may then matter whether the investment decision is made prior to or after the
bids have been placed. For simplicity we assume that investment is publicly observable but that bids may not be. We consider each of the three possibilities in turn.

Case 1) First consider the game in which investments are made prior the submission of final offers.

In this case, the game consists of three separate stages as follows:

1. Players 1 and 2 choose investments x and y respectively.
2. Players place final offer bids, b₁ and b₂ respectively.
3. The arbitrator chooses one of the two bids as the final allocation.

Stage 3: Arbitration

The arbitrator will choose the offer that lies closest to her true value denoted z which is chosen from the shifted distribution U[a + γ(x) – β(y), b + γ(x) – β(y)].

The arbiter’s decisions rule is to choose

\[ b_1 \quad \text{if} \quad |b_1 - z| < |z - b_2| \]

or \[ b_2 \] otherwise.

Given a cumulative density function F, then player two’s bid is chosen with probability \[ F((b_1 + b_2)/2) \]. Given this decision rule, the expected payout from player 2 to player 1 conditional upon investments x and y and bids b₁ and b₂ is shown in equation (1) below.

\[
E\pi_1 = b_1(1 - F(\frac{b_1 + b_2}{2})) + b_2F(\frac{b_1 + b_2}{2}).
\]  

(1)

Given the shifted uniform distribution, (1) can be rewritten as:

\[ E\pi_1 = b_1(1 - F(\frac{b_1 + b_2}{2})) + b_2F(\frac{b_1 + b_2}{2}) \]
Stage 2: Submission of Final Bids

Both players will choose their bids to maximize their expected profits in this round. Conditional upon x and y, maximization of (1) with respect to b₁ and b₂ shows that each player will choose to bid the endpoints of the distribution. In other words, b₁ = b + γ(x) − β(y) and b₂ = a + γ(x) − β(y). This is consistent with other work which shows that using the uniform distribution, players will bid the extremes of the distribution (See Farber 1980). Substitution into (1) yields respective expected payouts to players 1 and 2 of:

\[
E\pi_1 = \frac{b_1}{b-a} (b-a-(\frac{b_1+b_2}{2}-a-\gamma(x)+\beta(y))) + \frac{b_2}{b-a} (\frac{b_1+b_2}{2}-a-\gamma(x)+\beta(y))
\]

Stage 1: Investment Decisions

Player 1 will choose x to maximize (2a) while player 2 will choose y to minimize the expected payout in (2b). In so doing, the solution yields:

\[
\gamma(x) = \beta(y) = c.
\]

This leads to the following proposition.
**Proposition 1:** When investment decisions are made prior to the submission of final offer bids, expenditures are made until their marginal return in terms of shifting the distribution equals the marginal cost of the investment.

Incidentally, this is the same investment result that would arise in conventional arbitration where the arbitrator is free to impose $z$ as the payout.\(^3\)

**Case 2** Now consider the game in which investments are made after the submission of final offers that are observable to both players. In this case, the game consists of three separate stages as follows:

1. Players place final offer bids, $b_1$ and $b_2$ respectively.
2. Players choose investments $x$ and $y$ which shift the distribution of the arbitrator.
3. The arbitrator chooses one of the two bids as the final allocation.

**Stage 3: Arbitration**

This stage is solved exactly as before. Conditional upon both bids and investments, the arbitrator draws a value from the shifted distribution and chooses the bid that lies closer to that draw. The expected payout conditional upon bids and investments is the same as that found in (1).

**Stage 2: Investment Decisions**

In this case, players choose $x$ and $y$ conditional on the submitted bids. They choose $x$ and $y$ to maximize:

\(^3\) This can be seen from considering the payoff to player 1, $E\pi = (a + 2\gamma(x) + 2\beta(y) + b)/2 - cx$. Maximizing with respect to $x$ yields $\gamma'(x) = c$. 


\[ E\pi_1 = \frac{b_1}{b-a} (b-a-(b_1+b_2-a-\gamma(x)+\beta(y))) + \frac{b_2}{b-a} \left( \frac{b_1+b_2}{2} - a - \gamma(x) + \beta(y) \right) \]

\[ E\pi_2 = -\frac{b_1}{b-a} (b-a-(b_1+b_2-a-\gamma(x) + \beta(y))) - \frac{b_2}{b-a} \left( \frac{b_1+b_2}{2} - a - \gamma(x) + \beta(y) \right) - cy \] (3a, 3b)

For player 1, the choice of \( x \) satisfies:
\[ \frac{\gamma'(x)}{b-a}(b_1 - b_2) = c . \] (4a)

Performing a symmetric calculation for player 2 yields:
\[ \frac{\beta'(y)}{b-a}(b_1 - b_2) = c . \] (4b)

Denote the values of \( x \) and \( y \) that satisfy (4) as \( x^* \) and \( y^* \) where both \( x^* \) and \( y^* \) are clearly a function of the submitted bids.

**Stage 1: Submission of Final Bids**

When players choose their bids they have no information regarding the investment decisions. However, they can compute the reaction function in (4); therefore, they recognize the impact of their bids upon their opponent’s ultimate decision to invest. Thus, upon differentiating (3) with respect to the bids, players must consider the relationships \( dx^*/db_1, dx^*/db_2, dy^*/db_1 \) and \( dy^*/db_2 \) which are shown below.

\[ \frac{dx^*}{db_1} = \frac{-\gamma'(x^*)}{\gamma''(x^*)(b_1 - b_2)} \] (5a)

\[ \frac{dx^*}{db_2} = \frac{\gamma'(x^*)}{\gamma''(x^*)(b_1 - b_2)} \] (5b)
\[
\frac{dy^*}{db_1} = -\beta'(x^*) \frac{\beta''(x^*)(b_1 - b_2)}{\beta''(x^*)}
\] (5c)
\[
\frac{dy^*}{db_1} = \frac{\beta'(x^*)}{\beta''(x^*)(b_1 - b_2)}
\] (5d)

Optimization of equations (3a) and (3b) where x and y are both functions of b₁ and b₂ and substitution of (5) into the first order conditions generates the following solutions for the bids.

\[
b_1 = \frac{\beta'(y^*)^2}{\beta''(y^*)} - \gamma'(x^*)^2 \frac{c\gamma'(x^*)(b - a)}{\gamma''(x^*)(b_1 - b_2)} + b + \gamma(x) - \beta(y)
\] (6a)
\[
b_2 = \frac{\beta'(y^*)^2}{\beta''(y^*)} - \gamma'(x^*)^2 \frac{c\beta'(x^*)(b - a)}{\beta''(x^*)(b_1 - b_2)} + a + \gamma(x) - \beta(y)
\] (6b)

Again, recall that x* and y* are both functions of b₁ and b₂. If we assume that both players are equally productive in terms of the return on their investments (i.e. \(\gamma(x) = \beta(x)\)) then in equilibrium \(x^* = y^*\) and (6) simplifies to

\[
b_1 = \frac{c\gamma'(x^*)(b - a)}{\gamma''(x^*)(b_1 - b_2)} + b < b
\]

\[
b_2 = -\frac{c\beta'(x^*)(b - a)}{\beta''(x^*)(b_1 - b_2)} + a > a
\]

This implies that \(b_1-b_2 < b-a\), or that players’ bids will not be as extreme as in the case in which investments are made first. As a result, equation (4) implies that \(\gamma'(x) > c\); i.e., that the optimal value of x will be lower in this case since in case 1 player 1 increased x until \(\gamma'(x) = c\). Similarly, the optimal value of y will be less in this case as well.

**Proposition 2:** When players in FOA place their final offers prior to making their investment decisions, the bids will be more conservative and the investment spending will be lower relative to the case when they bid subsequent to making their investment.
Case 3) Now consider the game in which investments are made after the submission of final offers that are unobservable. In this case, the game consists of the following three stages:

1. Players place final offer bids, \( b_1 \) and \( b_2 \) respectively. Both bids are sealed.
2. Players choose investments \( x \) and \( y \) which shift the distribution of the arbitrator.
3. The arbitrator chooses one of the two bids as the final allocation.

Stage 3: Arbitration

This stage is solved exactly as before. Conditional upon both bids and investments, the arbitrator draws a value from the shifted distribution and chooses the bid that lies closer to that draw. The expected payout conditional upon bids and investments is the same as that found in (1).

Stage 2: Investment Decisions

In this case, players choose \( x \) and \( y \) conditional on their private information regarding their own bid but have no information regarding their opponent’s sealed bid. We find each player’s reaction function in which \( x \) and \( y \) are each a function of a player’s own bid as well as their opponent’s bid which is unknown to them. Players 1 and 2 choose \( x \) and \( y \) respectively to maximize equations (3a) and (3b) just as is shown in case 2 above. Their reaction functions are characterized by equations (4a) and (4b). While the equation look identical to case 2, in this case the opponent’s bid is not known and will be determined in equilibrium by a simultaneous solution to the reaction functions. Moreover, the equations differ between these cases in that the bids placed in stage 1 may differ from case 2, thereby yielding a different solution for \( x \) and \( y \). Denote the solution to investment decisions in this case as \( x^{**} \) and \( y^{**} \). Again, these values are both functions of the players’ own bids as well as their reaction to the unknown opponent’s bid and investment choice.
Stage 1: Submission of Final Offers

Similar to case 2 above, when players place their bids they must consider the response of the investment decision to that bid. However, in this case a player can only respond to his or her own investment choice. In other words, \( \frac{dx^{**}}{db_2} = \frac{dy^{**}}{db_1} = 0 \). The solution for \( \frac{dx^{**}}{db_1} \) and \( \frac{dy^{**}}{db_2} \) are the same as in equation (5). Players 1 and 2 choose bids to maximize (3a) and (3b) respectively, recognizing these relationships between the bids and the subsequent investment choices. The solution to each of these can be found in (7) below:

\[
b_1 = -\frac{\gamma'(x^*)^2}{\gamma''(x^*)} + \frac{c\gamma'(x^*)(b-a)}{\gamma''(x^*)(b_1-b_2)} + b + \gamma(x) - \beta(y) \quad (7a)
\]

\[
b_2 = \frac{\beta'(y^*)^2}{\beta''(y^*)} - \frac{c\beta'(x^*)(b-a)}{\beta''(x^*)(b_1-b_2)} + a + \gamma(x) - \beta(y) \quad (7b)
\]

Note that these expressions differ from (6a) and (6b) only in the absence of a single term from each equations. The term disappears as a result of the fact that players are not able to react to their opponents sealed bids; i.e., \( \frac{dx^{**}}{db_2} = \frac{dy^{**}}{db_1} = 0 \).

Once again, if we assume that players are identically productive in the return of investment on the shift of the arbitrator’s distribution (\( \gamma(x) = \beta(x) \) for all \( x \)), then (7) simplifies to

\[
b_1 = -\frac{\gamma'(x^*)^2}{\gamma''(x^*)} + \frac{c\gamma'(x^*)(b-a)}{\gamma''(x^*)(b_1-b_2)} + b \quad (8a)
\]

\[
b_2 = \frac{\beta'(y^*)^2}{\beta''(y^*)} - \frac{c\beta'(x^*)(b-a)}{\beta''(x^*)(b_1-b_2)} + a \quad (8b)
\]

Finally, substituting from equation (4) in for \( c \), (8) can be simplified to

\[
b_1 = b \quad (8a')
\]
\[ b_2 = a \]  \hspace{1cm} (8b')

which is identical to the bids in FOA in which observable investment occurs prior to bid submission.\(^4\) Given these equilibrium bids, equation (4) reveals that expenditures are also identical to that case.

*Proposition 3: When bids are made prior to investment decisions but they remain unobservable, the equilibrium value of bids and expenditure levels are identical to those when investments take place prior to final offers.*

*Corollary 1: The FOA case in which investments are made after the submission of publicly observable final offers leads to more moderate bidding behavior and less investment to shift the arbitrator’s distribution. There is no difference among FOA when bids are made first but are unobservable and FOA when bids are made subsequent to investments.*

3. Experimental Design

The policy implications of the above theory are clear, having the parties bid prior to investing leads to more reasonable behavior and results in lower costs. Using laboratory methods we compare behavior across the three FOA cases described above with the purpose of identifying how well the theory describes behavior and the likely impact of promoting such a prescription. Unlike naturally occurring disputes, in the laboratory we can control how investment affects the arbitrator’s likely choices and we can perfectly observe investment and offer choices. In the investment-public treatment, which corresponds to case 1, subjects privately and simultaneously invest first. Once both parties invest, the choices are revealed and then both parties place a final offer. After both final offers are made, the offers are revealed and the payoffs to both parties are determined. As in naturally occurring disputes, the actual choice of the arbitrator is not revealed. We also include an offer-public treatment, corresponding to case 2, in which
the sequence of choices is reversed. Finally, an offer-private treatment, corresponding to case 3, is similar to offer-public except that offers are not revealed until after investment choices have been made.

The experiment was divided into a series of decision periods. In each decision period, a pair of subjects had $EXP 3500 to allocate. The distribution used by the arbitrator had a support of $EXP 1000, i.e. $b-a = 1000$, but the location of $[a,b]$ was randomly determined each period. However, the endpoints of the distribution were common information at the beginning of the period. Allowing the arbitrator’s preferences to be randomly determined allowed us to ensure that the equal split of the entire surplus and the center of the arbitrator’s distribution differed without systematically favoring one party over the other across periods or relying upon an asymmetric distribution. Given that investment shifts the effective endpoints of the arbitrator’s distribution and university constraints will not allow subjects to lose their own money, $a$ must exceed 0 by at least the maximum value of $\gamma(x)$. Similarly, $b \leq 3500 - \max \beta(x)$.

Table 1 gives the values of the investment function, which is a discrete version of $\gamma(x) = 600 - 2.5(15-x)(16-x) = \beta(x)$. The information was presented to subjects in a table and not as a formula. The per unit cost of investment is $c = 15$. Under these parameters the optimal investment in offer-private and investment-public is $x = 13$ while in offer-public it is $x = 9$. The optimal offer in offer-private and investment-public is $b$ and the optimal offer in offer-public is $b - 211$. Given this particular investment function, $a \sim U[600, 1900]$. Recall that $b = a + 1000$.

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4 This result is also identical to that for conventional arbitration.
5 This function was chosen as it gave clear separation between offer-public and the other treatments.
6 At the optimal level of investment a disputant’s costs are approximately 15% of the amount under dispute. This level is consistent with previous work reported in Deck and Farmer (2005a,b) and Deck, Farmer and Zeng (2005), while Pecorino and Van Boening (2001) use arbitration costs ranging from 9% up to 80% of the value. Spier (1992) concludes that in standard litigation costs are 50% of the value while costs in arbitration are typically much lower.
Each laboratory session consisted of two phases. In the first phase subjects made investment and offer choices in accordance with the appropriate treatment for that session. Following these choices, the arbitrator rendered a final allocation. Every period subjects were randomly and anonymously matched with a counterpart. The first phase lasted fifteen periods. In the second phase of the experiment subjects were able to bargain with their counterparts for one minute by making offers and counteroffers back and forth. If the pair failed to reach a self negotiated agreement then the money was allocated as in the first phase (i.e., they placed a final offer and selected an investment level in accordance with the treatment, and then the arbitrator made a decision). The second phase lasted 5 periods with subjects being randomly and anonymously matched each period. The subjects did not know how many periods the first phase would last nor did they learn of the second phase until the end of the first phase. Breaking the experiment into two phases allows us to examine agreement rates and behavior in arbitration separately, thus avoiding the confounding factors that some previous studies have used to encourage disputes in order to observe more behavior in arbitration. In other words, this methodology prevented us from creating a design that would artificially generate settlement failure in order to be able to gather data regarding behavior in arbitration.

In each laboratory session six undergraduate subjects entered the lab and read the written directions. As subjects completed the directions, a comprehension quiz was

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7 Throughout the experiment neutral terminology was used, i.e. counterpart instead of opponent or partner.
8 See Deck, Farmer, and Zeng (2005) for a discussion.
9 Copies of the directions are available upon request.
administered. To aide subjects in completing the handout and to allow them to gain familiarity with the interface, the on-screen tool shown in Figure 1 was available and remained available throughout the experiment. Once all subjects had correctly completed the handout and had no more questions, the computerized experiment began. At the end of the experiment one decision period was randomly selected by a bingo cage and subjects were paid based upon their earnings in that period at the rate $EXP\ 100 = $US 1. Therefore, in the period that was selected subjects were bargaining over $35.00 and the arbitrator’s preferences had a range of $10.00. The sessions lasted one and half hours and the average earnings were approximately $24 including the $7.50 show-up fee.

Figure 1. On-Screen Tool

4. Experimental Results

The results are based upon twelve experimental sessions, 4 replicates of each of the three treatments. We have a total of 1080 observations (3 treatments $\times 4$ sessions/treatment $\times 6$ subjects/session $\times 15$ decisions/ subject) in the first phase and 348
in the second phase. Of course, observations are not independent within a session. To control for learning, behavior from the first five decision periods is omitted. We present the results as a series of findings in two parts; first we compare behavior across treatments and then we explore behavior within each treatment in more detail.

4.1 Bids and Investments Across Treatments

The typical measure of success for a dispute resolution procedure is the how infrequently parties rely upon it. However, from a social welfare perspective the measure of success is the (lack of) costs. In previous laboratory comparisons the costs have been constant across alternative procedures (see Deck and Farmer 2005a,b, Deck, et al. 2005, Dickinson 2004, Ashenfelter, Currie, Farber, and Spiegel 1992) so these two metrics coincide. But that need not be true here as costs are endogenously determined. Thus, a mechanism that generates a great deal of settlement but encourages a high level of investment when bargaining fails is not necessarily socially preferred. Our first two findings address both settlement rates and investment separately.

Finding 1. While the settlement rates do not differ statistically, the settlement rate is nominally highest in offer-public (60%) and nominally lowest in offer-private (53%).

Support: Figure 2 plots the self negotiated settlement rate by session in the second (bargaining) phase of the experiment. For the statistical comparison we rely upon the Kruskal-Wallis test for comparing $H_0$: no difference in the settlement rate across the three treatments vs. $H_a$: the settlement rate differs for some treatment. With a test statistic of 0.2, we cannot reject the null hypothesis.

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10 We planned to have 360 observations (3 treatments $\times$ 4 sessions/treatment $\times$ 6 subjects/session $\times$ 5 decision period/subjects), but due to time constraints one session only completed three decision periods in the second phase.
Figure 2. Settlement Rates by Session.

Note that theory does not offer a prediction regarding pre-arbitration settlement rates across cases. Given symmetric information, every case generates a contract zone in which both players would prefer settlement over pursuing arbitration. There exists a debate within the literature as to whether a larger or smaller contract zone is more conducive to settlement, but there is no clear prediction from theory on this issue. Previous experimental work by Deck and Farmer (2005a,b) indicates that a larger contract zone does in fact generate greater settlement. However, this is not supported here as offer-public is predicted to have lower costs and hence a smaller contract zone but it has the highest settlement rate.

Finding 2. As predicted by the theory less investment is exerted and hence costs are lower in offer-public than in offer-private. However, investment-public generates a similar reduction in investment even though it should not. (See corollary 1).

Support: For support we rely upon a mixed effects model that accounts for the repeated nature of the observations in the first phase of the experiment. The treatments are

11 In this experiment, there was no implicit cost of arbitration. In naturally occurring disputes, arbitration
modeled as fixed effects while the sessions and the subjects are treated as random effects. The results of the estimation are presented in Table 2. The Public term is a dummy variable that takes a value of 1 for both the investment-public and offer-public treatments. Hence the statistically significant -2.93 estimate on Public indicates that investment is lower in both of these treatments relative to the offer-private baseline. The lack of significance on OfferPublic, a dummy for the offer-public treatment, indicates that the reduction in investment is the same in offer-public and investment-public. The variable UpBound is the randomly selected value of b in a given period. Consistent with theory, the location of the arbitrator’s distribution does not affect investment.12

Together findings 1 and 2 suggest that offer-private is the least desirable from a social welfare perspective; it generates the nominally lowest rate of settlement and the highest level of investment costs. Another measure of performance is the degree of convergence in the bids made to arbitrator. A similar pattern emerges in comparing offers across treatments as formalized in finding 3.

Table 2. Mixed Effects Model for Investment

\[
\text{Investment}_{ijt} = \beta_0 + \varepsilon_i + \zeta_y + \beta_1 \text{Public}_i + \beta_2 \text{OfferPublic}_i + \beta_3 \text{UpBound}_t + \varepsilon_{ijt}
\]

where \(\varepsilon_i \sim N(0, \sigma^2_\varepsilon)\), \(\zeta_y \sim N(0, \sigma^2_\zeta)\), \(\varepsilon_{ijt} = \rho \varepsilon_{ij(t-1)} + u_{ijt}\), and \(u_{ijt} \sim N(0, \sigma^2_\varepsilon)\)

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</table>

\(\text{Investment}_{ijt}\) denotes the level of investment by subject \(i\) in session \(j\) during period \(t\).

Finding 3. As predicted by theory, offers are more extreme in offer-private than in offer-public. In contrast to the theoretical predictions offers in investment-public are similar to those in offer-public and less extreme than those in offer-private. (See corollary 1)

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12 An alternative specification allows each treatment to interact differently with \(\text{UpBound}\), but using a likelihood ratio test one fails to reject the null hypothesis that \(\text{UpBound}\) has the same effect in all three treatments (\(\chi^2\) statistic = 1.612, df = 2, and p-value = 0.45)
Support: We again rely upon a mixed effects model for support. The results for the treatment variables, presented in Table 3, demonstrate a similar pattern to those reported in Table 2. The optimal bid functions presented above are linear in b, but the coefficient on UpBound is less than one (t statistic = 5.55, df = 647, p-value <0.001). This indicates that when making offers subject behavior depends on the location of the arbitrator’s distribution.13 The direction is not too surprising given previous experimental work on bargaining. When the arbitrator favors the subject receiving the lion’s share of the $35.00, the subjects do not ask for as much of the $10.00 under dispute.

Note that findings 2 and 3 suggest that investment-public generates more moderate bidding and lower investment relative to offer-private than predicted by theory while offer-public generates moderated behavior as predicted. Possible explanations for this departure from theory in the investment-public case are discussed in section 4.

Table 3. Mixed Effects Model for Final Offers

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>df</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>113.1660</td>
<td>79.7952</td>
<td>647</td>
<td>1.4182</td>
<td>0.1566</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>-144.7689</td>
<td>64.6546</td>
<td>9</td>
<td>-2.2391</td>
<td>0.0519</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>55.2606</td>
<td>64.6546</td>
<td>9</td>
<td>0.8547</td>
<td>0.4149</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>0.8384</td>
<td>0.0291</td>
<td>647</td>
<td>28.8439</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

$Offer_{ijt}$ denotes the final offer by subject i in session j during period t.

4.2 Behavior Within Treatments

We now examine the treatments in greater detail. Since the subjects have different information and are predicted to make different investment and effort decisions, we analyze each treatment separately.

We first consider the offer-private treatment, (case 3 in the theory section) in which subjects make investment choices without learning of their counterpart’s offer. The optimal offer is the upper bound of the arbitrator’s distribution, b. As evidenced by

13 Again a likelihood ratio test fails to reject the null hypothesis that each treatment has the same response to a change in b ($\chi^2$ statistic = 2.244, df = 2, and p-value = 0.3256).
Table 3 and Figure 3, which plots the offers made in this treatment, there is considerable variation in offers, and offers tend to be less than $b$, a finding consistent with previous examinations of final offer arbitration. (See Ashenfelter, Currie, Farber, and Spiegel. 1992, Dickinson 2004, Deck and Farmer 2005a,b)

Figure 3. Offers in Offer-Private

![Graph showing offers vs. upper bound of arbitrator's distribution]

In this treatment, the optimal investment level is 13. Figure 4 plots the distribution of investment choices. While 13 was the modal response, on average subjects invested substantially less. This is also apparent from Table 2 where investment is estimated to be approximately 7.4 units.

We now turn our focus to the investment-public treatment (case 1), which generates the same theoretical predictions as the offer-private treatment. Figure 4 also plots the frequency of investment choices in investment-public, almost all of which are below 13. The distribution is dramatically shifted down relative to Offer-Private as was described in Table 2 (see finding 2). Based upon the estimates in Table 2, the average investment in this treatment is approximately 4.5.
In this treatment subjects have complete information on investment choices prior to placing an offer. Hence the optimal offer is $b + \gamma(x) - \beta(y)$. Thus the estimation presented in Table 3 is not appropriate for evaluating how closely observed offers match the theoretical predictions in this case. Therefore we estimated a mixed effects model for offers as a function of the adjusted upper bound just for this case; i.e., once we have data regarding actual investment, the appropriate question is whether their bids match the prediction ex post given that investment rather than ex ante given the theoretical prediction of investment. Table 4 presents the results of this estimation and Figure 5 plots offers relative to this adjusted upper bound. Again, as we saw in finding 3, we

Table 4. Mixed Effects Model for Final Offers in Investment-Public

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>df</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>283.9041</td>
<td>91.8089</td>
<td>215</td>
<td>3.0923</td>
<td>0.0022</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.6980</td>
<td>0.0376</td>
<td>215</td>
<td>18.5691</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

$Offer_{ijt}$ denotes the final offer by subject $i$ in session $j$ during period $t$. $AdjustedUpBound_{ijt}$ denotes the upper bound of the arbitrator’s distribution after it is adjusted for observed investment choices.
observe that subjects tend to be less aggressive in their offers the more favorable the distribution of the arbitrator. This is evidenced by the fact that the slope coefficient in Table 4 is less than one (t statistic = 8.0, df = 215, p-value <0.001) just as it was in Table 3.

Figure 5. Offers in Investment-Public

The remaining treatment, offer-public (case 2), is predicted to lead to less aggressive offers and lower investment than the other two treatments. In this treatment offers are placed prior to investment choices and, given the parameter choices, the optimal offer is $b - 211$. In Figure 6, which plots offers in offer-public, the offers appear to be closer to the optimal level than in the other treatments but still not as aggressive as predicted, as is consistent with the results in Table 3.

In equilibrium the optimal investment is 9. From Table 2 we know that realized investment is considerably less, approximately 4.5 units on average. Conditional on the observed offers, the optimal investment is given by equations (4a) and (4b). Thus some of the reduction in investment could be due to the lack of aggressive offers in the first stage. Figure 7 plots investment choices against the observed difference in offers. The data are not well described by the curve and there is considerable variation. Fifty three percent of the investment choices are below the conditionally optimal amount while only
thirty eight percent are above it. On average the investment is 1.5 units below the optimal level conditional on observed offers.

Figure 6. Offers in Offer-Public

Figure 7. Investment Choices in Offer-Public
The last three findings summarize the case specific analyses.

Finding 4 (Case 1). When disputants place offers after making observable investments, the level of those investments are substantially lower than predicted (4.5 instead of 13). Conditional on observed investments, disputants make less aggressive offers than they should.

Finding 5 (Case 2). When disputants place publicly observable offers prior to investing, consistent with theory, those offers are less aggressive than in the other treatments. Conditional on observed offers, investment expenditures are slightly below the predictions.

Finding 6 (Case 3). When disputants place offers without information regarding their counterpart’s investment, investments are lower than predicted (7.4 instead of 13) and offers are less aggressive than predicted. However, investments are larger and offers are more aggressive in this case relative to the other treatments.

5. Discussion

Previous work on final offer arbitration has focused exclusively on bidding. However, in final offer arbitration disputants face other strategic choices as well. The sequencing of these choices and the degree to which these choices are publicly observable impact the amount of investment and the aggressiveness of bidding by disputants.

From a theoretic standpoint, it is optimal to have disputants place bids that will become public prior to determining how much to invest. Most importantly, such a structure generates lower investments and thus greater social efficiency. Second, it should generate bids that are less aggressive. Less aggressive bids increase the probability of convergence so that parties reach a settlement without the need for an arbitrator’s decision; absent settlement, bids that are closer minimize risk faced by the players as well as any potential bias or error that could be introduced via the arbitrator’s
preferences. In contrast, both private bids and bids that occur after investments are made should generate higher investments and more extreme bids.

The behavioral results support the prediction that publicly observable bidding is (weakly) optimal. The observed investments are at least as low in this treatment and offers are no more aggressive than in the other treatments. Further, the settlement rates are nominally lower in this treatment. In comparing public versus private offers made prior to the investment decision, the change in behavior is consistent with the comparative static of the theory. Where the behavioral results deviate from the theoretical predictions is when public investments are made prior to the submission of bids. This case should be identical to the case when information remains private, but it is behaviorally similar to the case where bids are publicly observable. Simply stated, we find that when people are making decisions that are publicly observable, they tend to make less extreme choices.14

In all three treatments we find that subjects did not bid as aggressively as predicted by theory. This discrepancy is typical in final offer experiments, and our results support those previous works (see Ashenfelter et al 1992 and Deck and Farmer 2005b). Along those same lines, we find that investments were not as large as predicted for any treatment; this finding has not been investigated in any other setting.

Overall, we find that a mechanism in which players place publicly observable bids prior to making an investment decision is the socially optimal design theoretically and is weakly preferred to the other designs behaviorally. From a policy perspective these results suggest that players should be required to submit public final offers and then allow a round of negotiations during which players can choose the level of investment in developing and presenting a case. These results support Farmer and Pecorino (1998) and Pecorino and Van Boening (2001) in their findings that renegotiation after bid submission can encourage settlement when asymmetric information is present. While our results support this mechanism for entirely different reasons, this body of work supports the notion that behavior is mitigated when binding bids in FOA are be made public prior to negotiations. As there are no binding offers in conventional arbitration, our theory
suggests that FOA with public bids submitted prior to investment and effort decisions is socially preferred to CA as well.

\[14\] The result that people are less aggressive when they are more observable is similar to findings by Cox and Deck (2005), Charness, Haruvy, and Sonsino (2001), and Hoffman, McCabe, Shachat, and Smith (1994) examining the effect of social distance on behavior in other situations.
References


Charness, Gary, Ernan Haruvy, and Doron Sonsino, 2001. “Social Distance and Reciprocity: The Internet vs. the Laboratory,” Discussion paper, University of California at Santa Barbara, forthcoming in *Journal of Economic Behavior and Organization*.


Deck, Cary, Amy Farmer and Dao-Zhi Zeng. 2005 “Amended Final Offer Arbitration is Promising: Evidence from the Laboratory” University of Arkansas working paper.


Farmer, Amy and Paul Pecorino. 1999 “Legal Expenditures as a Rent-Seeking Game.” Public Choice, 100:271-88


The following pages contain the directions for each of the three treatments. The parenthetical comment at the top of each set indicates the treatment. This comment is included for the reader but was not present on the copies seen by subjects.
Experiment Directions (Offer-Public)

You are participating in a research experiment through IDEA (Interactive Decision Experiments at Arkansas). At the end of the experiment you will be paid your earnings in cash. Therefore, it is important that you understand the directions completely before beginning the experiment. If at any point you have a question, please raise your hand and a lab monitor will approach you. Otherwise you should not communicate with others (please turn off all cell phones, pagers, etc.).

Each period you will randomly be assigned a counterpart among the other participants. There is $EXP 3500 to be allocated between you and your counterpart each period. That is, the amount allocated to your counterpart is $EXP 3500 minus the amount allocated to you. At the end of the experiment you will be paid your allocation (minus any costs you incur) for one randomly selected period. Earnings are converted at the rate is $EXP 100 = $US 1 so amounts are in cents.

**How is the money allocated?** You have probably seen two people decide who got something by each guessing a number from 1 to 10 while a neutral third person did the same. The person guessing the number closest to the third person’s choice got the item. The process for allocating the money in today’s experiment is similar to that except that all the money does not go to the person who picks the closest number. Instead, you will be allocated an amount of money equal to the closest number and your counterpart will get the rest.

In the case of picking a number from 1 to 10 this would mean that if you said 8 and your counterpart said 1 while the third person picked 6 you would be closer and get 8 leaving 2 for your counterpart. But if the third person had said 4 then your counterpart would be closer so you would get 1 leaving 9 for your counterpart. Since your choice is about how much money will be allocated to you, it is referred to as an offer (you are offering to be allocated some amount and leave the rest for your counterpart). Similarly, your counterpart is offering an amount to be allocated to you.

In today’s experiment you and your counterpart will be making offers with $EXP 3500. Thus your offer can be any integer between 0 and 3500 inclusive. In other words, your offer can be 0, 1, 2, ..., 3448, 3449, 3500. Your counterpart will also make an offer from 0 to 3500 about how much is to be allocated to you. During the period you will have the opportunity to invest in order to adjust the computer’s draw upward, but any investment you make is costly to you. Your counterpart will also have the opportunity to make costly investments which will adjust the computer’s draw downward. The computer’s random number adjusted for the investments will then be compared to the two offers. The final allocation will be the offer closest to the adjusted computer draw. If the two offers are equally far from the adjusted computer draw, then one of the two offers will be randomly selected to be the allocation.

- If your offer is closer to the adjusted computer’s draw, then your allocation will be your offer, leaving $3500 minus your offer for your counterpart.
- If your counterpart’s offer is closer to the adjusted computer’s draw, then your allocation will be your counterpart’s offer, leaving $3500 minus your counterpart’s offer for your counterpart.
What numbers could the computer pick? The computer will have a range of 1001 numbers from which to randomly pick. The location of this range is randomly determined each period. That is, in one period the computer might be picking a number between 1035 and 2035 and in another period it might be picking a number between 2165 and 3165. The range of possible values the computer might pick will be displayed on your screen throughout the period.

Order of events in a period
1. You and your counterpart will each make an offer.
2. You and your counterpart will observe each other's offers.
3. You and your counterpart will each select how much to invest.
4. The computer will draw a number, adjust it for investment, and determine the allocation.
5. You and your counterpart will both be informed of the results.

Your screen will have four parts. The large yellow box is an on-screen tool for you to use during the experiment. It allows you to see what would happen under different scenarios. When you supply hypothetical choices of how much you and your counterpart will invest, hypothetical offers for you and your counterpart, and a hypothetical draw for the computer this tool will tell you what the payoffs to you and your counterpart would be. What you do in this yellow box is just for your information and it will not impact your actual payoff. The slider for the computer's draw gives the actual 1001 number interval from which the computer will draw.

<table>
<thead>
<tr>
<th>Period</th>
<th>My Offer</th>
<th>DP's Offer</th>
<th>My Cost</th>
<th>DP's Cost</th>
<th>My Payoff</th>
<th>DP's Payoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>1000</td>
<td>100</td>
<td>100</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>1000</td>
<td>100</td>
<td>100</td>
<td>2000</td>
<td>2000</td>
</tr>
</tbody>
</table>
The light blue area at the top of the screen tells you what information you know when making a choice. Since you will not know your counterpart’s choices and will not have selected your cost when you make your offer these items have a “?”. To make an offer you simply type the amount of your offer in the box and press “Submit Offer.” Once you press this button you cannot change your mind.

The dark blue box on the right shows how much money you have to invest to adjust the computer’s draw. This is the same table that your counterpart will use. For example, if you invest $EXP 120, 460 will be added to the computer’s random draw. If your counterpart invests $EXP 180, then 570 will be subtracted from the computer’s draw.

After you and your counterpart both make an offer, you will each be able to observe the offers in the light blue box at the top of your respective screens. You will then be able to select a cost by highlighting a row of the table in the dark blue box and clicking on “Submit Cost.” Once you press this button you cannot change your mind.

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After you and your counterpart both make an offer, you will then be able to select a cost by highlighting a row of the table in the dark blue box and clicking on “Submit Cost.” Once you press this button you cannot change your mind.

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