An Experimental Comparison of Alternative Arbitration Systems

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Abstract

In recent years various types of arbitration systems have been adopted to replace more costly methods for settling disputes in labor agreements, commercial contracts and in the courtroom. This paper reports the first systematic experimental comparison of the effect of the alternative arbitration systems on dispute rates. Every arbitration hearing involves three parties. We simplify this three party bargaining problem by modeling arbitral decisions as random draws from a fixed distribution. The resulting two party bargaining problem is easily implemented in the laboratory.

Our subjects either negotiate settlements or arrive at an impasse: Impasses are resolved by resorting to an arbitrator and an arbitration system. Different arbitration systems can be compared since all the arbitrator's decisions are drawn from the same distribution. Hence, the arbitrator's decisions are entirely controlled for when the results of behavior under the various arbitration systems are compared.

Our purpose in implementing these experiments has been a limited one: We were primarily interested in whether our procedures for simulating arbitrator decisions would produce behavior by the bargainers in a laboratory setting that was comparable to the results we see for bargainers in the field. Remarkably, where comparisons may be made, we find that the operating characteristics of our laboratory experiments are not qualitatively different from what has been observed in the field for the various arbitration systems.

Introduction

In recent years various types of arbitration systems have been adopted to replace more costly methods for settling disputes in labor agreements, commercial contracts and in the courtroom. This paper reports the first systematic experimental comparison of the effect of the alternative arbitration systems on dispute rates. Although there has been considerable speculation over whether arbitration systems "chill" bargaining and decrease the incidence of negotiated settlements,[1] it has been difficult to obtain direct evidence on the matter. Likewise, claims for the superiority of alternative arbitration systems at inducing negotiated settlements have been hard to assess. Although several alternative arbitration systems exist in the field, so many other factors differ where these systems are (and are not) used that a simple comparison of dispute rates provides little compelling evidence. Arbitration systems are so carefully structured, however, that it seems natural to compare their results with each other and with the absence of an arbitration system in a controlled laboratory environment. The stumbling block to this approach in the past has been the difficulty in handling the inherent three-party nature of arbitration systems. Structuring the incentives for the bargaining parties has been done successfully on many occasions in the laboratory setting, but how are the incentives for the arbitrator to be determined?[2]

A primary innovation in this paper is to simulate arbitrator behavior by implementing the emerging results from field studies that indicate that acceptable arbitrator decisions contain a random component.[3] The key idea is the following: Since the parties play a role in the selection of the arbitrator who will decide their dispute, arbitrators who are known to favor one of the parties are eliminated. This selection process creates incentives for arbitrators to maintain characteristics that make them (statistically) exchangeable with other arbitrators. In effect, three-party bargaining can be reduced to two-party bargaining because actual negotiations are broken into two parts: (a) the parties mutually select the arbitrator, and (b) the parties present their cases to the arbitrator selected.

Under these circumstances, the arbitration decisions in the second part of the bargaining may be modeled as random draws from a fixed distribution. The evidence from field studies provides strong support for this characterization of arbitrator behavior. We therefore simulated arbitrator behavior in the bargaining experiments reported below by exploiting this simple idea.

The result is that an apparently complex bargaining problem may be simplified and easily implemented in the laboratory. Bargainers either negotiate settlements or arrive at an impasse: Impasses are resolved by resorting to an arbitrator and an arbitration system. Different arbitration systems may be implemented by the experimenter who is secure in the knowledge that all the arbitrator's decisions are drawn from the same distribution. In this sense the arbitrator's decisions are entirely controlled for when the results of behavior under the various arbitration systems are compared.

Our purpose in implementing these experiments has been a limited one: We were primarily interested in whether our procedures for simulating arbitrator decisions would produce behavior by the bargainers in a laboratory setting that was comparable to the results we see for bargainers in the field. Remarkably, where comparisons may be made, we find that the operating characteristics of our laboratory experiments are not qualitatively different from what has been observed in the field for the various arbitration systems. We therefore think the results of our experiments may be of considerable interest to those interested in the practical design of arbitration systems and to those interested in theories intended to describe how the parties behave in actual bargaining situations. Our methods also hold out the opportunity for considerable additional useful experimentation.

In the first section of the paper we discuss the theoretical issues which are experiment was designed to test. Section two describes the experimental setup. In the third section, we report the main experimental results and contrast them with the known operating characteristics of the same arbitration systems operating in the field. Although our experiments are not designed specifically to test theories which seek to explain the occurrence of disputes in an arbitration system, in the fourth section we offer some tentative evidence on this issue too.

1: Theoretical Concerns

The growing theoretical literature on the nature of alternative arbitration mechanisms has raised a number of issues whose resolution requires empirical inquiry. In conventional arbitration, for example, the arbitrator fashions an award based on an analysis of the relevant facts and the arbitrator's external judgement of what would comprise a fair award. Conventional arbitration is alleged to discourage, or "chill", good faith bargaining, because if the parties believe that the arbitrator will "split-the-difference" between them, they will be encouraged to adopt extreme bargaining positions. In order to neutralize the chilling effect of arbitration, Stevens (1966) suggested final-offer arbitration in which the arbitrator must choose the final offer of one of the parties without compromise. Stevens claimed that since extreme offers were unlikely to be chosen, the incentive to posture before the arbitrator would be reduced and good-faith bargaining would be more likely to occur.

Crawford (1979) argued that if on the contrary, the arbitrator's exogenously determined notion of a fair settlement were known to the two parties, then both arbitration mechanisms would lead to the same outcome in a zero-sum setting. The key to Crawford's conclusion is the assumption that both parties know with certainty the arbitrator's preferred outcome. In a series of papers Farber and Katz, and Farber (1979, 1980), have explored the opposite case in which the parties are uncertain about the arbitrator's preferred outcome.

In Farber and Katz' (1979) model of conventional arbitration, two parties A and B, bargain over the share of a "pie" of fixed size that A will receive. The size of the pie can be normalized to one, so that if A receives a share of ya, B receives yb=(1-ya). The two parties have constant absolute risk aversion utility functions of the form: $U_i=[1-\exp(y_i*c_i)]/[1-\exp(c_i)]$, where ci is the coefficient of absolute risk aversion and i=A,B.

If the dispute goes to arbitration, the arbitrator will make an award, y, based on the facts of the case and on her own notions about equity. The parties have common beliefs about the distribution of arbitrated outcomes: $y \sim N(y^e, s^2)$. Using the moment-generating function for the normal, the minimum outcome that a party would accept with certainty rather than facing the uncertainty involved in going to arbitration can be defined as: $y_i^c = y^e + .5s^2c_i$, where y_i^c is called the "certainty equivalent" outcome. The "contract zone" of settlements that both parties would prefer to arbitration is $[(1-y_b) - y_a]$ which can be re-written as $-.5s^2(c_a+c_b)$. Parties have a dispute if and only if this term is less than zero. This condition is satisfied if the sum of the coefficients of risk aversion is positive. Hence, only pairs who are "on average" risk loving, have disputes.

The model can easily be generalized by allowing parties to have differing beliefs about the distribution of arbitral outcomes. Then the larger the contract zone, the greater the divergence in beliefs that will be required to generate a dispute. The discussion above makes clear that the contract zone will be larger, the greater the amount of uncertainty about the distribution of the arbitrator's preferred outcomes. Hence, we expect greater uncertainty to be associated with fewer disputes.

Farber (1980) extends the model to the case of final-offer arbitration. In the event of a dispute, each party makes a final offer to the other. Arbitrators are assumed to choose the final offer closest to their own exogenously determined preferred outcome. Thus, the probability that B's proposal is chosen by the arbitrator is $F((ya+yb)/2)$ where F is the cumulative normal density function. Similarly, the probability that A's proposal is chosen is $[1-F((ya+yb)/2)]$.

The contract zone of offers that both parties would accept rather than go to arbitration can be derived assuming Nash equilibrium behavior. One first computes the expected utility of each party under arbitration at the equilibrium offers, and then takes the difference of the certainty-equivalent outcomes. Once again the model predicts that, given the same beliefs, only pairs who are on average risk lovers will use arbitration.

In order to test this implication of the model, we can compare the actual final offers made to the Nash equilibrium final offers risk-neutral parties would make. If the actual offers are more conservative than the risk-neutral ones, the inference is that the pair is risk-averse rather than risk-loving.

The Nash equilibrium risk-neutral offers can be derived as follows: Let A's utilities at $ya=1$ and $ya=0$ be normalized to one and zero respectively. If A is risk neutral then UA(ya)=ya, where UA denotes A's utility function. Therefore, A's expected utility is given by:

(1) $E(UA(ya))=F((ya+yb)/2)yb + [1-F((ya+yb)/2)]ya$

and the first order condition from A's expected utility maximization problem is:

(2) $.5*f((ya+yb)/2)(yb-ya) + [1-F((ya+yb)/2)] = 0$

where f is the normal density function. Similarly, B's first order condition when B is risk neutral is:

(3) $.5*f((ya+yb)/2)(ya-yb) - F((ya+yb)/2) = 0$

Equations (2) and (3) implicitly define the Cournot reaction functions. If the reaction functions cross, then an equilibrium to the Nash game exists. Brams and Merrill (1983) show that in the special case considered here, (risk neutral parties, a zero-sum game, and a normal distribution of arbitral preferred outcomes), a global equilibrium exists.[4] Moreover, the equilibrium risk-neutral offers must be equi-distant from the median of the distribution of arbitral outcomes.

A problem in the final-offer situation is that, one cannot tell that a party is risk averse by looking only at their individual offer. An offer less conservative than the risk-neutral one is compatible with risk neutrality if the other party is either very risk averse or very risk loving. Intuitively, if one party makes an offer that is unlikely to be accepted by the arbitrator, a risk-neutral opponent will take advantage of the fact by making a less conservative offer themselves. Nevertheless, if both parties make conservative offers, we can conclude that they are both risk averse.

The expected utility maximization framework can be extended straight-forwardly to the case of tri-offer arbitration, a form of arbitration which has been implemented in Iowa's public service. In this form of arbitration, disputes are first submitted to a fact-finder who suggests an award. If the parties are still unable to agree, the dispute goes to an arbitrator who must choose either of the parties' final offers or the fact-finder's suggested award. We assume that the parties take the fact-finder's offer and their opponent's offer as given and set their own offers at levels that maximize expected utility.

In Appendix 1 we show that a) utility maximizing parties never set their offers equal to the fact-finder's offer, and b) for fact-finder's offers which are sufficiently high (low) it will be optimal for both parties to make offers below (above) the fact-finder's offer. As the fact-finder's offer becomes arbitrarily large for example, the parties find themselves in what is essentially a final-offer situation since there is little probability that the fact-finder's offer will be chosen, and they set their offers accordingly. We can test the expected utiltiy maximization framework by looking at whether parties' final offers move in the predicted way with the fact-finder's offer.

Finally, we show that in the most common case in which parties' offers bracket the fact-finder's offer, whether or not a party is risk averse can be directly inferred from their individual offer.

In summary, the theory suggests that we use our experimental data to look at: a) whether arbitration has a chilling effect on bargaining and if so whether the effect is larger for conventional or final-offer arbitration; b) whether increasing the uncertainty associated with arbitration reduces the number of disputes; c) whether the expected utility maximization framework adequately describes the behavior of the parties; and d) whether parties that have disputes make risk-loving offers on average.

2: Design of the Experiments

Two considerations were responsible for the bargaining framework in which we embedded our experiments. First, we were anxious to establish parallels between the field setting in which arbitration systems operate and those we constructed in the laboratory. At the same time, we did not want to rely on the role playing that previous experimenters have induced in the experimental bargainers. Hence, our bargainers were given direct financial incentives to reach an agreement.

Second, we wanted to set up a bargaining framework in which costly disputes would occur naturally. As a result of these considerations, we elected to place the bargainers in a series of repeated pie-splitting games. We assumed that if the size of the pie were known, the parties would select a 50-50 split and that few disputes would occur. We therefore did not tell either bargainer the size of the pie to be divided, but we did inform the bargainers that they would face the same opponent in all rounds. We expected the repeated nature of the bargaining and the unknown size of the pie to induce some disputes based on our observations of other bargaining experiments, although we had no way of knowing whether this would be the case before the experiments were begun.[5]

It is our impression that this setup is the simplest that maintains some element of comparison to a typical bargaining situation in the field. In labor and commercial arbitration, and even in civil litigation, it is typically the same parties, or their agents, who are engaged in settling repeated disputes. Likewise, the parties to an arbitration agreement usually have a relationship-specific investment of unknown value to the other party. Thus, neither side is likely to know just what the other is prepared to sacrifice in order to reach an agreement, but disagreements are continuously resolved over the course of the relationship.

A: Procedures.

Our bargaining experiments were conducted in the summer of 1984, and the winter of 1988, using Plato software at the University of Arizona. Subjects were recruited from students at the University, a subject pool that has been used extensively for laboratory experiments in economics. Upon arrival at the laboratory, a subject was placed at a computer terminal and given instructions containing the basic information necessary to send, receive and accept offers. Subjects did not know the identity of their opponents, who were situated at different computer terminals some distance away. Precautions were built into the software to ensure that subjects could not inadvertently accept offers.

We employed a classical design in the test of the experimental arbitration systems. All subject pairs bargained twenty rounds. Twenty of the subject pairs were placed in a control group and these pairs bargained without the presence of an arbitration system throughout all twenty rounds. One-hundred-and-thirty-three subject pairs bargained ten rounds without the presence of an arbitration system and ten rounds in the presence of an arbitration system.

B: The Control Group.

Twenty pairs of subjects bargained in the absence of an arbitration system throughout the experiment. They were told that the pay-off would be zero for any round in which a settlement was not reached. Each pair in this control group bargained for twenty rounds with a five-and-one-half minute time limit on each round. While players always knew how much time was left in the round, and what round they were in, they were not told the number of rounds that would take place.

The bargaining protocol in each round was deliberately left unstructured, as is naturally the case in the field. Each party's last offer was posted on their screen and on their opponent's screen at all times. An offer consisted of a number between 100 and 500. The subjects were given a schedule revealing the cash value of various settlements to them, but they were not given the schedule of their opponent. In fact, their opponent's schedule was identical except that odd numbered parties desired high outcomes, while even numbered parties desired low outcomes. Thus, although never told so, the parties were participating in a simple pie-splitting game. An agreement at 300 split the pie, which contained $1.20, in half. The least a subject could earn was $.15 per round, and the most $1.05. Thus, if the parties continually agreed to split the pie, each would earn $12. for an effort that took one to one-and-one-half hours. We reckoned these stakes to be at least double the hourly wage available to our subjects.

C: Conventional Offer, Final Offer and Tri-Offer Experiments.

One hundred and thirty three pairs bargained ten rounds without arbitration followed by ten rounds with arbitration. In rounds without arbitration, failure to reach a settlement resulted in a zero pay-off, while in rounds with arbitration the arbitrator dictated a division. Initially, the only information subjects received about the type of arbitration was that their actions would have no bearing on the arbitrator's decisions.[6] A detailed description of the dispute resolution procedure under arbitration was given only after the tenth round.

In the conventional arbitration experiments disputes were settled by randomly generating a number between 100 and 500. The number chosen became the contract price. In the event of an impasse in the final-offer experiment, each party submitted a final offer. The offer closest to the chosen random number became the contract price. Parties were told which final offer was selected, but they were not given the actual random number generated. In the tri-offer arbitration experiment a "fact-finder" was brought in if no settlement had been reached after two and three-quarter minutes. The fact-finder randomly generated a contract price which the parties could either accept or reject. If either party rejected the proposal, the pair was given another two and three-quarter minutes to reach an agreement. If no settlement occurred after five minutes, the two parties submitted final offers. Of the three offers on the table, the one closest to a random number drawn from the distribution of arbitral preferred outcomes was chosen. The fact-finder's proposal was drawn from the same normal distribution as the arbitrator's award.[7]

In order to compare dispute rates under the three different forms of arbitration, three experiments were run with different types of arbitration but with the same distribution of arbitral outcomes. Twenty-five pairs bargained subject to conventional-offer arbitration, twenty-six pairs bargained subject to final-offer arbitration and twenty-eight were subject to tri-offer arbitration. These subjects were all told that the arbitrator's decision would be modeled as a random draw from a normal distribution with mean 350 and a standard deviation of 50. The players also were given the arbitrator's last 100 "decisions" and told that future decisions would be consistent with previous ones.

In order to assess the effect of the degree of uncertainty associated with arbitral outcomes on dispute rates, two additional conventional-offer experiments were conducted, in which the variance associated with arbitral outcomes was changed first to 25 and then to 12.5. These experiments involved twenty-five and twenty-nine pairs respectively. We will refer to these experiments as medium and low-variance conventional arbitration while the first conventional arbitration experiment is called high variance.

Note that in all the experiments involving arbitration, the arbitrator was biased in favor of the odd-numbered party. This bias was intended to move the bargaining pairs away from mechanical 50-50 divisions of the pie.

3: Experimental Results vs. Arbitration Experience in the Field

A: Dispute Rates.

The number of disputes per round for each type of arbitration are displayed in Table 1. Experimental dispute rates under arbitration ranged from 28 to 43 percent. Results reported by Lester (1984), Ashenfelter and Bloom (1984), Babcock (1988), Ashenfelter, Dow, and Gallagher (1985) and Neelin (1988), suggest that these dispute rates are in line with those observed in the field.

A comparison of rounds with arbitration to rounds without in Table 1, suggests that arbitration does "chill" bargaining: in rounds without arbitration, dispute rates ranged from four to fourteen percent. In the conventional-offer arbitration cases, increases in the uncertainty associated with arbitration were associated with decreases in dispute rates. Given that uncertainty can be regarded as perhaps the major cost associated with arbitration, these results suggests that disputes will be less frequent when they are more costly. The table also shows that contrary to Steven's hypothesis, final-offer and tri-offer arbitration are associated with higher, rather than lower dispute rates than conventional-offer arbitration.

The statistical significance of these results is tested using logit models in Table 2. The null hypothesis that dispute probabilities are the same regardless of the variance associated with the distribution of arbitral outcomes is rejected at the ninety-five percent level of confidence, as is the hypothesis that the type of arbitration does not matter.[7]

B: Win-loss Records in Final-offer and Tri-offer Arbitration.

Table 3 shows the win-loss records of parties involved in final-offer and tri-offer arbitration. Under final-offer, odd numbered parties won roughly twice as many cases as even numbered ones. Also, odd-numbered parties tended to submit conservative offers, relative to the mean of the arbitrator's distribution. These results are puzzling in light of the random assignment of subjects to even and odd positions, and may be related to the fact that the arbitrator was biased in favor of odd-numbered parties.

Forty percent of the experimental cases which proceeded to the last stage of tri-offer arbitration were won by the fact-finder, compared to 64 percent of similar cases in Iowa. The difference in these figures reflects the fact that in Iowa one of the disputants matched the fact-finder's offer in almost half of the cases going to arbitration. In contrast, there were only two instances in which an experimental subject matched the fact-finder's offer. It was clear to our experimental subjects that arbitrators would not place extra weight on the fact-finder's recommendation. As we show in Appendix 1, in this case, expected utility maximizing parties' would never select the fact-finder's offers. If parties believed instead that the arbitrator valued agreement with the fact-finder, then one would expect the pile-ups on the fact-finder's offer that one sees in Iowa.

C: Contract Prices.

A breakdown of mean negotiated contract prices by type of arbitration appears in Table 4. There are no statistically significant differences in contract prices by type of arbitration or degree of uncertainty. Mean negotiated contract prices are uniformly higher in the rounds with arbitration than in the rounds without, although again the differences are not statistically significant. This result suggests that biased arbitrators can influence the pattern of negotiated as well as arbitrated settlements, and that odd numbered parties did exploit the strategic advantage conferred on them by the arbitrator's bias, although not to the fullest extent possible.

4: Are Pairs that Have Disputes Expected Utility Maximizers?

(Some Preliminary Evidence).

Given that parties should have had the same beliefs about the distribution of arbitral outcomes, Farber's model predicts that pairs that have disputes should show risk-loving behavior. This implication of the model is tested below by comparing the actual offers to the Nash equilibrium risk-neutral ones. This testing procedure avoids the specification of a particular utility function and eliminates the need to know a subject's initial wealth. Our data show that parties that had disputes often made offers that indicate risk aversion, although statistically, it is difficult to reject the null hypothesis that parties are risk neutral.

Finally, leaving aside the question of why disputes occur, we examine the tri-offer data to see whether given that a dispute occurs, parties' final offers move with the fact-finder's offer in the way predicted by expected utility-maximization. We find that they do. Since computing the risk-neutral offer is quite difficult, this is a remarkable result.

A: Risk Aversion in the Conventional-Offer Experiments.

The expected utility of submitting a dispute to an arbitrator under conventional arbitration is the utility associated with the mean award. A risk averse party should be willing to accept less than this amount in order to avoid the uncertainty associated with arbitration. Hence, a comparison of the actual offers with the mean of the distribution of arbitral awards can be used to determine whether or not a party is risk averse. The offers are shown in Appendix 2. At least one party made a risk loving offer in every case in which there was a dispute.

B: Risk Aversion in the Final-Offer Experiments.

Farber's (1980) model of final-offer arbitration, in which the parties choose offers which maximize their expected utilities given the other party's offer, is used to compute the risk-neutral offers for cases that went to final-offer arbitration. The risk-neutral offers are then compared with the actual offers. If the actual offers are more conservative than the risk-neutral ones, the conclusion drawn is that the parties to the dispute are risk averse rather than risk loving. The proof that more risk averse parties make offers that are conservative relative to the risk-neutral ones is consigned to Appendix 1.

Given the mean and the variance of F, the equilibrium risk-neutral offers can be found by solving (2) and (3). The normalized mean share of F is .6250 and the variance is .0160. The risk-neutral offers are ya=.7816 and yb=.4683 which are equidistant from the mean share. The actual and risk-neutral offers are shown in Appendix 2. Many parties who had disputes made offers more conservative than the risk-neutral ones.

As shown in Appendix 1, pairs can only be said to be risk averse if both made conservative offers because the equilibrium risk-neutral offer depends on the offer of ones opponent. By this criteria, four of the sixteen pairs who had disputes under final-offer arbitration can be identified as risk averse.

However, the average mean difference between actual and risk-neutral offers, computed over the 32 individuals who had disputes, and normalized so that negative differences indicate risk aversion, is .0005 with a standard deviation of .147. Thus, we cannot reject the null hypothesis that, on average, subjects were attempting to make risk-neutral offers.

C: Risk Aversion and the Tri-Offer Experiment.

The actual and risk-neutral offers for the tri-offer case are shown in Appendix 2.[8] Five observations were lost because one party made an offer equal to the fact-finder's. In the remaining 85 disputes, 31 pairs made offers that were both below the fact-finder, 11 made offers that were both above the fact-finder, and 43 made offers bracketing the fact-finder's offer. These latter observations are of greatest interest, because in this case, a party's risk neutral offer does not depend on his/her opponent's offer. Hence, each individual's offer can be compared with the risk-neutral offer in order to determine whether or not the person is risk averse. Twenty-eight odd and twenty-five even offers (out of the 43) indicate risk aversion. The mean difference between actual and risk-neutral offers for each member of the twenty-three pairs that had disputes, (normalized so that negative differences indicate risk averse behavior), was .095 with a standard deviation of .056. Hence, the null hypothesis that parties who had disputes were attempting to make risk-neutral offers cannot be rejected at the ninety-five percent level of confidence.

Stronger evidence of expected utility maximizing behavior is shown in Plots 1 and 2. Because the risk-neutral offers vary with the fact-finder's offer, there is enough variation in the former to make plotting actual versus risk-neutral offers an interesting exercise. The plots show that the actual offers do tend to move with the risk-neutral ones.

A final prediction of the expected utility maximization framework is that whether the parties choose to place their offers both below, both above, or around the fact-finder's offer should depend on the fact-finder's offer. Regime switching does in fact vary in the right direction: The mean fact-finder's offer is highest in cases where both parties placed their offers below it, and vice-versa. In fact, the mean fact-finder's offer is .71 in this case, .62 in the case where the parties offers straddle the fact-finders, and .5 in the case where they both exceed the fact-finder's. These results provide evidence that subjects' behavior can be described using an expected utility maximization framework.

5: Conclusions

Modelling arbitral decisions as random numbers drawn from a normal distribution worked well in that dispute rates and win/loss records were in line with those observed in the field. We found evidence of a substantial "chilling" effect of arbitration. We did not find any evidence that final or tri-offer arbitration reduced the incidence of disputes. Increases in the uncertainty associated with conventional-offer arbitration were associated with decreases in arbitration rates, which supports the view that uncertainty associated with arbitral outcomes is an important cost associated with arbitration.

Attempts to associate disputes with risk-loving behavior produced mixed results. Under conventional-offer arbitration, at least one party made a risk-loving offer in every case in which there was a dispute. Our experimental design was such that in the final and tri-offer experiments, we could not always tell whether or not individual players were risk averse. We do note that in the empirically important tri-offer situation in which parties make offers which bracket the fact-finder's proposal, it is possible to use individual offers to assess risk aversion.

The data for this case suggest that many players who had disputes made risk-averse rather than risk-loving offers. But given the complexity of the problem, and the fact that the offers are not statistically significantly different that the risk-neutral ones, the hypothesis that parties were attempting to make risk-neutral offers cannot be rejected. Certainly, little support is found for the hypothesis that parties have disputes because they are on average risk-loving.

On a more positive note, the fact that actual offers move with risk-neutral ones, and that regime switching varies correctly with the fact-finder's offer, supports the hypothesis that once parties have a dispute, they make offers which maximize their expected utilities.

Our intention was to illustrate the potential usefulness of a simple experimental approach to the evaluation and modeling of arbitration systems. We hope that the results presented above will prove sufficiently provocative that other researchers will consider an experimental approach to these problems.

1. For a brief survey of the "chilling effects" literature see Ehrenberg and Schwartz, pages 49 to 51.

2. Arbitration experiments which did not explicitly model the arbitrator's behavior have been conducted by DeNisi and Dworkin (1981), Grigsby and Bigoness (1982), Johnson and Tullar (1972), Magenau (1983), Neale and Bazerman (1983), Notz and Starke (1978), Starke and Notz (1981), and Sabbarao (1978).

3. See Ashenfelter and Bloom (1984), Farber and Bazerman (1986), Bloom (1987), and Ashenfelter, Dow and Gallagher (1985). Ashenfelter (1987) is a non-technical survey of these results.

4. Since offers must lie between zero and one, the correct distribution is a truncated normal. However, the truncation points are far enough away from the mean of the distribution that correcting for truncation had virtually no effect on the probability of an offer being selected.

5. It is our impression that virtually all bargaining experiments result in some Pareto-inefficient disputes. Such disputes are usually neither desired nor discussed by the experimenters who encounter them. An exception is Roth and Ochs (1988) who show that in a range of two person bargaining experiments conducted by different researchers using different subject groups, about 15% of negotiations end in disputes.

6. We were afraid that the subjects might alter their bargaining strategies in the early rounds, in the hope of influencing the arbitrator's decisions later on. The instructions were designed to minimize this problem.

7. Ashenfelter, Dow and Gallagher test and accept the hypothesis that fact-finders have the same distribution of preferences as arbitrators in Iowa. Since fact-finders are often drawn from the same pool as arbitrators it seems reasonable to assume that the distribution of preferences is the same for the two groups.

8. The risk-neutral offer depends on whether the parties' offers are both above the fact-finder's, both below, or on either side. Here, the risk-neutral offers are computed conditional on the observed configuration of the offers.

Table 1

Number of Disputes/Number of Pairs in Each Cell Per Bargaining Round

		Arbitration Type in Rounds 11-20						
		Conventional				Tri-Offer		
	No Arbitration	High-Variance Arbitrator ($\sigma = 50$)	Medium-Variance Arbitrator ($\sigma = 25$)	Low-Variance Arbitrator ($\sigma = 12.5$)	Final Offer	Total	Settled After Factfinder	Not Settled After Factfinder
Round:								
1	1/10	3/25	2/25	6/29	2/26	4/28		
2	0/10	1/25	3/25	3/29	4/26	6/28		
3	0/10	5/25	4/25	7/29	2/26	5/28		
4	1/10	3/25	2/25	2/29	2/26	2/28		
5	0/10	0/25	4/25	3/29	5/26	3/28		
6	1/10	4/25	5/25	2/29	2/26	4/28		
7	0/10	3/25	1/25	5/29	3/26	4/28		
8	1/10	1/25	1/25	5/29	3/26	4/28		
9	0/10	2/25	3/25	2/29	2/26	3/28		
10	0/10	2/25	1/25	5/29	3/26	3/28		
11	0/10	6/25	7/25	12/29	10/26	12/28	2/28	10/28
12	1/10	9/25	9/25	13/29	8/26	13/28	2/28	11/28
13	0/10	5/25	6/25	12/29	11/26	12/28	0/28	12/28
14	0/10	7/25	10/25	12/29	10/26	9/28	3/28	7/28
15	0/10	7/25	6/25	8/29	11/26	14/28	5/28	10/28
16	1/10	11/25	5/25	14/29	10/26	11/28	6/28	6/28
17	0/10	6/25	10/25	10/29	7/26	9/28	4/28	6/28
18	0/10	8/25	7/25	11/29	12/26	13/28	3/28	11/28
19	0/10	3/25	9/25	12/29	10/26	17/28	5/28	12/28
20	0/10	9/25	10/25	15/28	9/25	8/26	1/26	9/26
Total:								
Rounds 1-10	4/100	24/250	26/250	40/290	28/260	38/280		
Rounds 11-20	4/100	71/250	79/250	119/289	98/259	118/278	31/278	87/278
Percentages:								
Rounds 1-10	0.040	0.096	0.104	0.138	0.108	0.136		
Rounds 11-20	0.040	0.284	0.316	0.412	0.378	0.426	0.112	0.313

Table 2

Logit Analysis of the Effect of Arbitration Type on Dispute Probabilities

Arbitration Type:

No* Arbitration	Conventional: High Variance	Conventional: Medium Variance	Conventional: Low Variance	Final Offer	Tri-Offer	-2 Log Like-lihood
Effect of Arbitration Types is Unconstrained:						
-1.04 (.352)	1.09 (.164)	1.25 (.161)	1.67 (.147)	1.53 (.153)	1.75 (.148)	2767.20
Effect of Conventional Arbitration Types Restricted to Equality:						
-1.04 (.352)	1.36 (.113)	-	-	1.53 (.154)	1.75 (.148)	2778.26
Effect of All Arbitration Types Restricted to Equality:						
-1.04 (.352)	1.48 (.102)	-	-	-	-	2785.65

* Left out category is the first 10 rounds of rounds with arbitration. Critical values for the x^2 with 2 and 4 degrees of freedom are 5.99 and 9.48, respectively.

Table 3

Win-Loss Records in Experimental Arbitration Sessions
Final Offer Arbitration

Bargaining Pair Number	Fraction Odd-Numbered Bargaining Wins
1	3/3
2	6/10
3	4/8
4	5/9
5	0/0
6	4/6
7	0/0
8	0/0
9	4/6
10	1/4
11	0/0
12	8/9
13	5/8
14	3/5
15	3/4
16	0/0
17	0/0
18	2/3
19	0/0
20	3/8
21	5/5
22	5/5
23	0/0
24	2/3
25	0/0
26	0/0

Total: 63/96
($t = 3.06$ for H_0 48/96)

Table 3 (Continued)

The Disposition of Disputes in Tri-Offer Arbitration

Bargaining Pair Number	Post-Factfinder Settlement	Factfinder Proposal Accepted	Odd Wins	Even Wins	Factfinder Wins	Total
1	2	1	5	2	0	10
2	2	0	1	2	4	9
3	0	2	0	2	1	5
4	1	3	2	1	2	9
5	4	0	1	0	0	5
6	0	0	0	0	0	0
7	0	4	0	0	2	7
8	0	3	3	0	1	9
9	0	0	0	1	2	3
10	0	0	3	0	1	4
11	0	0	4	0	5	9
12	0	0	2	5	2	9
13	0	1	3	1	2	7
14	0	0	0	0	0	0
15	0	0	0	0	1	1
16	0	0	0	0	0	0
17	0	0	0	0	1	1
18	0	2	0	0	0	2
19	0	1	0	1	0	2
20	0	0	0	1	2	3
21	0	1	0	1	1	3
22	0	2	1	1	1	5
23	0	0	0	0	0	0
24	0	1	0	1	4	7
25	0	0	1	0	2	3
26	0	2	3	0	0	6
27	0	0	0	2	0	2
28	0	0	0	0	3	3
Total	9	23	29	21	37	124

Table 4

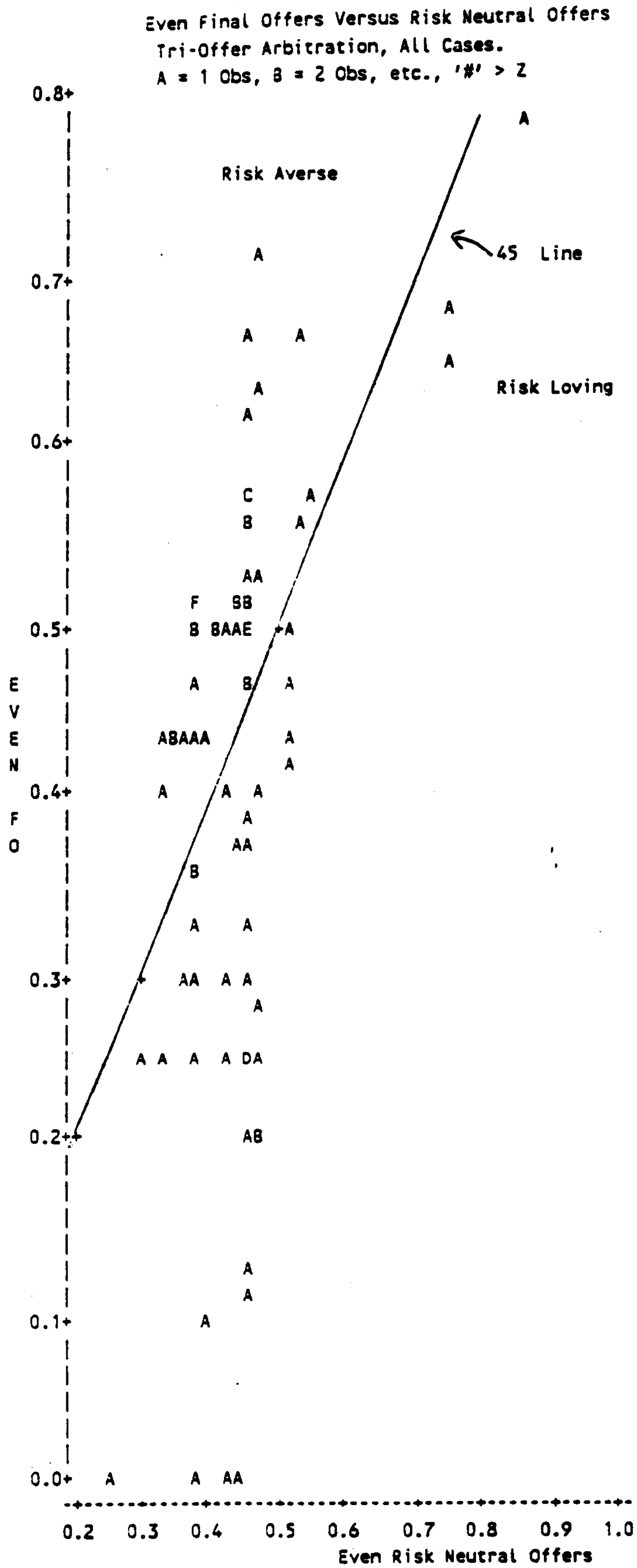
Mean Negotiated Contract Prices

Rounds	Untrimmed Sample 1-10	Untrimmed Sample 11-20	Trimmed Sample 1-10	Trimmed Sample 11-20
Type:				
Final Offer	286.4	296.9	311.5	320.9
	(17.8)	(16.0)	(15.8)	(13.1)
Tri-Offer	271.1	303.4	301.7	334.7
	(14.3)	(18.8)	(10.9)	(13.5)
Low Variance Conventional	266.8	281.9	295.2	313.9
	(13.0)	(15.4)	(9.3)	(9.2)
Medium Var. Conventional	300.6	316.9	320.2	331.9
	(17.3)	(17.4)	(15.3)	(15.0)
High Variance Conventional	308.8	354.0	321.7	354.0
	(16.5)	(16.3)	(15.1)	(16.3)

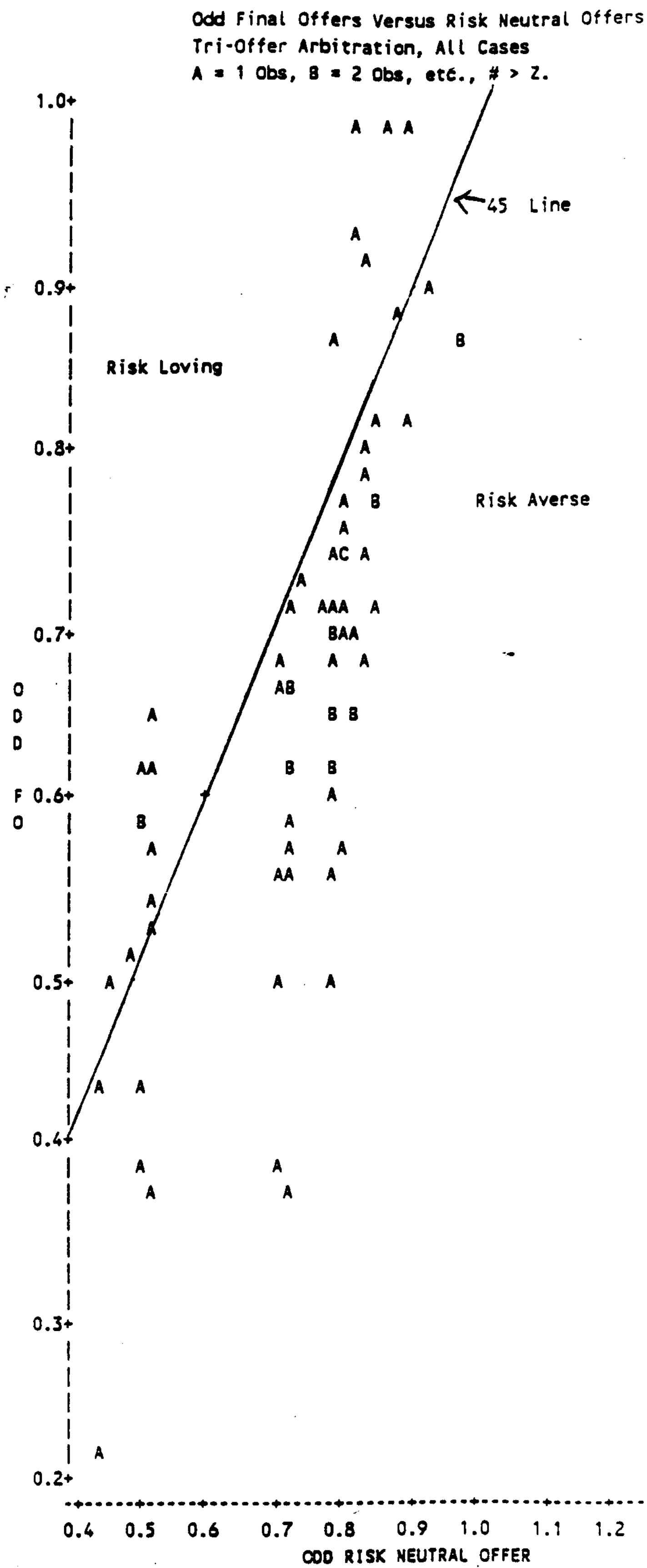
The number in parentheses are standard errors.

The trimmed sample includes only those pair who reached an average contract over 200.

Plot 1


Even Final Offers Versus Risk Neutral Offers
Tri-Offer Arbitration, All Cases.
A = 1 Obs, B = 2 Obs, etc., '#' > Z
Risk Averse
45 Line
Risk Loving
EVEN FO
Even Risk Neutral Offers

Plot 2


Odd Final Offers Versus Risk Neutral Offers
Tri-Offer Arbitration, All Cases
A = 1 Obs, B = 2 Obs, etc., # > Z.
45 Line
Risk Loving
Risk Averse
ODD FO
ODD RISK NEUTRAL OFFER

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Appendix 1

Proposition 1: More risk averse parties submit "conservative" offers.

Proof: The parties bargain over the share of a "pie" of fixed size that party A will receive. The size of the pie is normalized to one, so that if party A receives a share of y, party B receives (1-y). Denote A's proposal by ya and B's proposal by yb. It is trivial to show that ya > yb. The probability that B's proposal will be adopted is F((ya+yb)/2) where F is a single peaked symmetric distribution of the arbitrator's preferred outcomes. Here, F denotes the cumulative normal density function. Similarly, the probability that ya is chosen is [1-F((ya+yb)/2)].

Let A's utilities at y=1 and y=0 be normalized to 1 and zero respectively, and assume that A is risk neutral. Then UA(y)=y, where UA denotes A's utility function. Therefore, A's expected utility is given by:

(1) $E(UA(ya)) = F((ya+yb)/2)yb + [1-F((ya+yb)/2)]ya$

and the first order condition from A's expected utility maximization problem is

(2) $(1/2)f((ya+yb)/2)(yb-ya) + [1-F((ya+yb)/2)] = 0$

where f is the normal density function. Similarly, B's first order condition when B is risk neutral is

(3) $(1/2)f((ya+yb))/2)(ya-yb) - F((ya+yb)/2) = 0$

Let ca and cb be the risk aversion parameters associated with UA and UB. Formally, we need to show that the derivative of ya with respect to ca is negative while the derivative of yb with respect to cb is positive everywhere. Write the first order conditions as:

(4) $g1(ya,yb,ca) = (1/2)f((ya+yb)/2)[UA(yb)-UA(ya)] + [1-F((ya+yb)/2)]UA'(ya) = 0$ and

(5) $g2(ya,yb,cb) = (1/2)f((ya+yb)/2)[UB(ya)-UB(yb)] - F((ya+yb)/2)]UB'(yb) = 0$

Totally differentiating and applying Cramer's rule yields:

$$(6)\ \delta ya/\delta ca = -\begin{vmatrix} \delta g1/\delta ca & g1b \\ 0 & g2b \end{vmatrix} \Big/ \begin{vmatrix} g1a & g1b \\ g2a & g2b \end{vmatrix}$$

where gia is the partial derivative of gi with respect to ya, etc. A similar expression can be derived for $\delta yb/\delta cb$.

To sign these expressions, note that the Jacobian in the denominator must be positive if the Nash game characterized by (4) and (5) is to have a stable solution.[16] Also, if the expected utility functions are concave then $g1a < 0$ and $g2b < 0$. If the expected utility functions are not concave then the solutions of (4) and (5) do not maximize the expected utilities.

Finally, it can be shown that the derivative of g1 with respect to ca is negative, while the derivative of g2 with respect to cb is positive: Consider a function ZA(y) such that $-ZA''(y)/ZA'(y) > -UA''(y)/UA'(y)$ for all y. Arrow and Pratt show that ZA is everywhere more concave than UA. Hence, it can be shown that there exists a function VA(y) which represents the same preferences as ZA(y) such that $VA(y)=UA(y)$, $VA'(y)=UA'(y)$, and $VA(y) < UA(y)$ for all y not equal to ya. Thus,

(2)' $g1=(1/2)f((ya+yb)/2)[VA(yb)-VA(ya)]+[1-F((ya+yb)/2)]/VA'(ya) < 0$

but the utility function VA reflects a higher degree of risk aversion on the part of A than does UA. Hence, the derivative of g1 with respect to ca is less than zero. A similarly defined function VB(1-y) can be used to demonstrate that the derivative of g2 with respect to cb > 0. Hence $\delta ya/\delta ca < 0$ and $\delta yb/\delta cb > 0$ everywhere. Thus, given their opponent's degree of risk aversion, a more risk averse person will make a more conservative offer.

Proposition 2: In tri-offer arbitration, it is never optimal to make an offer equal to the fact-finder's proposal.

Proof that yb<ya=yff is not a possible equilibrium:

Compare

(1) $E(UA(ya')) = F((yb+yff)/2)UA(yb) + [F((yff+ya')/2) - F((yb+yff)/2)]UA(yff) + [1-F((yff+ya')/2)]UA(ya')$

to

(2) $E(UA(ya^*)) = F((yb+ya^*)/2)UA(yb) + [F((ya^*+yff)/2) - F((yb+ya^*)/2)]UA(ya^*) + [1-F((ya^*+yff)/2)]UA(yff)$

where ya* is the optimal offer such that ya ≤ yff and ya' is the optimal offer such that ya > yff.

If ya* is set equal to yff then (2) becomes

(2)' $F((yb+yff)/2)UA(yb) + [F(yff)-F((yb+yff)/2)]U(yff) + [1-F(yff)]UA(yff)$

But (1) > (2)[1] always. Note that the first terms cancel. Also, the terms in F([yb+ya]/2) cancel. But

(3) $[UA(ya')-UA(yff)][1-F((yff+ya')/2)] > 0$

by the definition of ya'. Hence it is never optimal for A to set ya=yff.

A similar argument can be used to show that it is never optimal for party B to set yb=yff.

Proposition 3: If the fact-finder's offer is sufficiently high, both parties will make offers below it.

Proof that $yb<ya<yff$ is a possible equilibrium:

Given yff and yb, A's expected utility if ya is set below yff is:

$$(1)\quad E(UA(ya^*)) = F((yb+ya^*)/2)UA(yb) + [F((ya^*+yff)/2) - F((yb+ya^*)/2)]UA(ya^*) + [1-F((ya^*+yff)/2]UA(yff)$$

where ya* is the optimum value of ya given yb and yff. As yff becomes arbitrarily large, F((ya+yff)/2) approaches one. For concave expected utility, [1-F()]UA(yff) approaches zero so that E[UA(ya)] takes the same form as the expected utility calculation under final offer arbitration. (See equation (1), section 1). Thus ya must approach the offer A would select under final offer arbitration which is finite, and hence less than yff.

It can also be shown that given ya and a sufficiently low value of yff, person B will choose a value of yb greater than yff. Therefore, $yff<yb<ya$ is a possible equilibrium.

Proposition 4: In equilibrium, the parties may choose to place their offers on either side of the fact-finder's proposal.

Proof: Proposition 2 implies that while the expected utility of A may be quasi-concave given $ya>yff$ or given $ya<yff$, it will not be quasi-concave in the neighborhood of $ya=yff$. hence, it is not clear that an equilibrium will always exist such that $yb<yff<ya$. Let the utility maximizing value of yb such that $yb<yff$ be denoted yb' and let the corresponding value such that $yb > yff$ be denoted yb*. If B jumps from yb' to yb* at the same value of yff that causes A to switch from ya* to ya', then $yb'<ya^*<yff$ and $yff<yb^*<ya'$, are the only possible equilibrium configurations.

In order for both A and B to jump at the same time, six equations must be satisfied. First, the expected utility of A at ya* must equal the expected utility of A at ya', and the same must hold for B at yb* and yb'. Se cod, ya*, ya', yb*, and yb' must be chosen to satisfy the relevant first or deconditions. This system of six equations in five unknown is:

1. $E(UA(ya^*)) - E(UA(ya')) = 0$

Hence, $F(\frac{yb' + ya^*}{2})[UA(yb') - UA(ya^*)]$

$+ F(\frac{yb' + yff}{2})[UA(yff) - UA(yb')]$

$+ (1 - F(\frac{ya' + yff}{2}))[UA(yff) - UA(ya')]$

$+ F(\frac{ya^* + yff}{2})[UA(ya^*) - UA(yff)] = 0$

2. $E(UB(yb')) - E(UB(yb^*)) = 0$

Hence, $F(\frac{yb' + yff}{2})(UB(yff) - UB(yb'))$

$$+ F(\frac{yff + yb*}{2})(UB(yff) - UB(yb*))$$

$$+ F(\frac{yb* + ya'}{2})(UB(yb*) - UB(ya'))$$

$$+ F(\frac{yff + ya'}{2})(UB(ya') - (UB(yff)) = 0$$

3. First order condition for ya' is satisfied

$$\frac{1}{2} f(\frac{yff + ya'}{2})(UA(yff) - UA(ya')) + (1 - F(\frac{yff + ya'}{2})) = 0$$

4. First order condition for ya* is satisfied

$$\frac{1}{2} f(\frac{yb' + ya*}{2})[UA(yb') - UA(ya*)]$$

$$+ \frac{1}{2} f(\frac{ya* + yff}{2})[UA(ya*) - UA(yff)]$$

$$+ [F(\frac{ya* + yff}{2}) - F(\frac{yb' + ya*}{2})] = 0$$

5. First order condition for yb' is satisfied

$$\frac{1}{2} f(\frac{yb' + yff}{2})(UB(yb') - UB(yff)) + F(\frac{yb' + yff}{2}) = 0$$

6. First order condition for yb* is satisfied

$$\frac{1}{2} f(\frac{yff + yb*}{2})(UB(yb*) - UB(yff))$$

$$+ \frac{1}{2} f(\frac{yb* + ya'}{2})(UB(ya') - UB(yb*))$$

$$+ F(\frac{yb* + ya'}{2}) - F(\frac{yff + yb*}{2}) = 0$$

In general these equations will not be satisfied except by coincidence.

First Order Conditions for Tri-Offer Arbitration

(In each case the solutions yield the risk-neutral offers.)

Case 1: $yb < ya < yff$

FOC A: $\frac{1}{2} f(\frac{yb + ya}{2}) (yb - ya) + \frac{1}{2} f(\frac{ya + yff}{2}) (ya - yff)$

$+ F(\frac{ya + yff}{2}) - F(\frac{yb + ya}{2}) = 0$

FOC B: $\frac{1}{2} f(\frac{yb + ya}{2}) (ya - yb) - F(\frac{yb + ya}{2}) = 0$

Case 2: $yff < yb < ya$

FOC A: $\frac{1}{2} f(\frac{yb + ya}{2}) (yb - ya) + [1 - F(\frac{yb + ya}{2})] = 0$

FOC B: $\frac{1}{2} f(\frac{yff + yb}{2}) (yb - yff) + \frac{1}{2} f(\frac{yb + ya}{2}) (ya - yb)$

$+ F(\frac{yff + yb}{2}) - F(\frac{yb + ya}{2}) = 0$

Case 3: $yb < yff < ya$

FOC A: $\frac{1}{2} f(\frac{yff + ya}{2}) (yff - ya) + [1 - F(\frac{yff + ya}{2})] = 0$

FOC B: $\frac{1}{2} f(\frac{yb + yff}{2}) (yff - yb) - F(\frac{yb + yff}{2}) = 0$

Appendix 2: Equilibrium Risk Neutral, and Actual Offers.

Comparison of Actual and Risk Neutral Offers in the Low Variance Conventional Arbitration Case. (LO=last offer, DODD and DEVEN =1 if offer indicates risk aversion.)

PAIR	ODD LO	DODD	EVEN LO	DEVEN
1	0.6375	0	0.5000	0
1	0.6550	0	0.6025	0
1	0.6375	0	0.6000	0
1	0.6250	0	0.6000	0
2	0.6000	1	0.4375	0
2	0.5750	1	0.4750	0
2	0.6225	1	0.5000	0
2	0.6125	1	0.4375	0
2	0.6250	0	0.3750	0
2	0.6225	1	0.5000	0
3	0.7500	0	0.3500	0
3	0.6000	1	0.3325	0
3	0.6750	0	0.3875	0
3	0.6375	0	0.2500	0
3	0.6000	1	0.4500	0
3	0.6750	0	0.5000	0
3	0.6625	0	0.6000	0
3	1	0	0.6000	0
3	1	0	0.5225	0
4	0.6250	0	0.1250	0
4	0.9475	0	0.5625	0
4	0.8650	0	0.6125	0
4	0.6775	0	0.6100	0
5	0.9000	0	0.1750	0
5	0.7750	0	0.3750	0
5	0.8750	0	0.4975	0
5	0.7200	0	0.5250	0
5	0.6750	0	0.5775	0
6	0.6875	0	0.6075	0
8	0.7125	0	0.3750	0
8	0.7000	0	0.3550	0
8	0.7500	0	0.4900	0
8	0.6375	0	0.4400	0
8	0.7500	0	0.3750	0
8	0.7125	0	0.4500	0
9	0.3750	1	0.2500	0
10	0.4775	1	0.3750	0
12	0.5000	1	0.2500	0
13	0.7875	0	0.3000	0
13	0.7625	0	0.3125	0
13	0.8375	0	0.1000	0
13	0.8875	0	0.1625	0
13	0.8625	0	0.1500	0
13	0.8500	0	0.1625	0
13	0.8750	0	0.1250	0
13	0.6875	0	0.4125	0
13	0.7500	0	0.4625	0
15	0.4250	1	0.3500	0
15	0.5000	1	0.3500	0
15	0.4750	1	0.3500	0
15	0.5500	1	0.3750	0
15	0.6250	0	0.4750	0
15	0.6125	1	0.4475	0
15	0.6250	0	0.4250	0
16	0.6250	0	0.5225	0
16	0.6500	0	0.5225	0
16	0.6250	0	0.5225	0
16	0.6750	0	0.5225	0
16	0.6125	1	0.5225	0
16	0.6250	0	0.5500	0
16	0.6125	1	0.5500	0
16	0.6125	1	0.5625	0
17	1	0	0.2500	0
17	0.5625	1	0.3750	0
17	0.6000	1	0.4875	0
17	0.5625	1	0.4000	0
17	0.5750	1	0.4625	0
17	0.6250	0	0.3500	0
17	0.6250	0	0.4875	0
17	0.6000	1	0.4750	0
17	0.6375	0	0.3750	0
18	0.5500	1	0.5000	0
18	0.5500	1	0.5000	0
19	1	0	0.3500	0
19	1	0	0.1500	0
19	1	0	0	0
20	0.5475	1	0.5375	0
20	0.5925	1	0.5625	0
20	0.5900	1	0.5800	0
20	0.6225	1	0.5750	0
22	0.8250	0	0.6375	1
23	0.8150	0	0.5175	0
23	0.7000	0	0.5700	0
23	0.8125	0	0.5600	0
23	0.8250	0	0.5525	0
23	0.8875	0	0.5625	0
23	0.8125	0	0.5425	0
24	0.6750	0	0.3375	0
24	0.6250	0	0.3250	0
24	0.8000	0	0.5000	0
24	0.7500	0	0.5000	0
27	0.6250	0	0.5375	0
27	0.9975	0	0.5450	0
27	0.9975	0	0.5500	0
27	0.9975	0	0.5375	0
27	0.9975	0	0.5625	0
27	0.9975	0	0.5550	0
27	0.9975	0	0.5750	0
27	0.9975	0	0.6150	0
27	0.6725	0	0.6500	1
28	0.7500	0	0	0
28	0.9975	0	0.2500	0
28	1	0	0.4500	0
28	1	0	0.5225	0
28	1	0	0.5000	0
29	0.9975	0	0.2750	0
29	0.9975	0	0.2750	0
29	0.8625	0	0.3125	0
29	0.7425	0	0.5000	0
29	0.7100	0	0.5500	0
29	0.6650	0	0.5750	0
29	0.9975	0	0	0
29	0.6650	0	0.2500	0
30	0.7250	0	0.4625	0
30	0.5475	1	0.4750	0
30	0.6000	1	0.4600	0
30	0.5000	1	0.4375	0
30	0.5225	1	0.4875	0
30	0.7500	0	0.5000	0

Continued - Medium Variance Conventional Offer Arbitration.

PAIR	ODD LO	DODD	EVEN LO	DEVEN
1	0.9475	0	0.3750	0
1	0.9000	0	0.3750	0
1	0.9125	0	0.3750	0
2	0.6675	0	0.5750	0
2	0.6750	0	0.5750	0
2	0.6750	0	0	0
2	0.6850	0	0.5750	0
2	0.6750	0	0	0
2	0.6825	0	0	0
2	0.6625	0	0	0
2	0.6975	0	0	0
2	0.6500	0	0	0
3	0.6175	1	0.5625	0
3	0.6250	0	0.5875	0
3	0.8125	0	0.6000	0
3	0.8125	0	0.5000	0
3	0.6875	0	0	0
3	0.6500	0	0	0
3	0.6500	0	0.6125	0
3	0.6500	0	0.6125	0
3	0.6600	0	0	0
4	0.4925	1	0.2500	0
4	0.6000	1	0.5050	0
4	0.6250	0	0.2500	0
5	0.6750	0	0.5625	0
5	0.6500	0	0.6250	0
5	0.6875	0	0.4500	0
5	0.6750	0	0.5250	0
5	0.7525	0	0.2875	0
7	0.9975	0	0.5600	0
7	0.8875	0	0.8750	1
7	0.9125	0	0.6475	1
7	0.9000	0	0	0
7	0.9500	0	0	0
8	0.8500	0	0.7500	1
8	0.8500	0	0.7500	1
8	0.7500	0	0	0
8	0.7475	0	0.6250	0
8	0.7500	0	0.6250	0
9	0.9250	0	0	0
10	0.5750	1	0.4375	0
10	0.4500	1	0.4125	0
10	0.5000	1	0.4225	0
11	0.5875	1	0.2225	0
11	0.5875	1	0.4625	0
11	0.6125	1	0.4975	0
11	0.5750	1	0.5700	0
11	0.5875	1	0.2475	0
11	0.6250	0	0	0
12	0.8750	0	0.3750	0
12	0.9975	0	0.0025	0
12	0.8650	0	0.0025	0
12	0.8650	0	0.0025	0
12	0.5375	1	0.0025	0
12	0.8750	0	0.0025	0
12	0.8650	0	0.0025	0
12	0.5625	1	0.5000	0
13	0.7250	0	0.3125	0
14	1	0	0.0875	0
16	0.7475	0	0.1375	0
16	0.9975	0	0.1750	0
16	0.7500	0	0.2775	0
16	0.9975	0	0	0
16	0.9975	0	0.3625	0
16	0.9975	0	0.3250	0
17	0.7025	0	0.5500	0
17	0.6975	0	0.4500	0
17	0.7125	0	0.4750	0
17	0.6875	0	0.5750	0
17	0.6750	0	0.5625	0
17	0.6250	0	0.4975	0
17	0.9975	0	0.5250	0
18	0.3050	1	0.2500	0
18	0.7475	0	0.4700	0
18	0.9975	0	0.3625	0
22	0.6375	0	0	0
22	0.6875	0	0.5275	0
24	0.8375	0	0.5500	0
24	0.8750	0	0.5375	0

Continued - High Variance Conventional Arbitration

PAIR	ODD LO	DODD	EVEN LO	DEVEN
1	0.7500	0	0.3750	0
1	0.6875	0	0.2875	0
1	0.7500	0	0.3500	0
1	0.7450	0	0.2550	0
1	0.7500	0	0	0
1	0.7500	0	0.3750	0
1	0.7500	0	0.2750	0
1	0.7500	0	0.2500	0
1	0.7500	0	0.2500	0
1	0.7375	0	0.5125	0
2	0.6000	1	0.5125	0
2	0.6500	0	0.5000	0
2	0.6500	0	0.5625	0
2	0.6625	0	0.5625	0
2	0.6125	1	0.5750	0
2	0.7500	0	0.5000	0
2	0.6250	0	0.5500	0
3	0.5250	1	0.4250	0
3	0.6250	0	0.5000	0
3	0.9975	0	0.2500	0
3	0.6250	0	0.5000	0
4	1	0	0.3750	0
4	0.8125	0	0.6250	0
4	0.8750	0	0.4875	0
4	0.8750	0	0.5000	0
4	0.9375	0	0.5250	0
4	0.9375	0	0.5625	0
4	0.9375	0	0.6250	0
5	0.8750	0	0.3750	0
5	0.7775	0	0.3750	0
5	0.4975	1	0.4750	0
5	0.9850	0	0.5825	0
5	0.9975	0	0.4225	0
6	0.5625	1	0	0
6	0.6500	0	0.5500	0
6	0.5500	1	0.5275	0
6	0.6000	1	0.4425	0
6	0.5000	1	0.4600	0
6	0.7000	0	0.4450	0
7	0.8750	0	0.3125	0
7	0.8250	0	0.4625	0
7	0.7250	0	0.5000	0
7	0.7000	0	0.5125	0
7	0.7375	0	0	0
7	0.9375	0	0.5925	0
7	0.9975	0	0.5875	0
7	0.9625	0	0.5875	0
7	0.9975	0	0.0275	0
8	0.7000	0	0.4325	0
10	0.2750	1	0.3250	0
13	0.7500	0	0	0
15	0.4125	1	0.3250	0
15	0.7500	0	0.6125	0

PAIR	ODD LO	DODD	EVEN LO	DEVEN
16	0.6475	0	0	0
16	0.6950	0	0.5900	0
16	0.6625	0	0.6000	0
16	0.6250	0	0.5750	0
16	0.6500	0	0.5900	0
16	0.6375	0	0.5750	0
17	0.9850	0	0.9825	1
18	0.5725	1	0.5650	0
18	0.5750	1	0.5650	0
19	1	0	0	0
22	0.5000	1	0.2500	0
22	0.6350	0	0.3500	0
22	0.7500	0	0.5000	0
22	0.9250	0	0.5825	0
22	0.9125	0	0.5000	0
24	0.7125	0	0.5250	0
24	0.5250	1	0.5025	0
24	0.6050	1	0.2500	0

Comparison of Actual and Risk Neutral Offers: Final Offer Arbitration
(FO=final offer. DODD=1. DEVEN=1 if offer indicates risk aversion.)

PAIR	ODD FO	DODD	EVEN FO	DEVEN
1	0.4500	1	0.1125	0
1	0.5750	1	0.2000	0
1	0.5675	1	0.2200	0
2	0.8000	0	0.3750	0
2	0.7925	0	0.4000	0
2	0.7625	1	0.4150	0
2	0.7375	1	0.4700	1
2	0.7125	1	0.4700	1
2	0.7125	1	0.4750	1
2	0.7125	1	0.5500	1
2	0.7000	1	0.5775	1
2	0.7500	1	0.4700	1
2	0.7500	1	0.3775	0
3	0.6000	1	0.4975	1
3	0.5750	1	0.4875	1
3	0.5500	1	0.5350	1
3	0.5875	1	0.5375	1
3	0.5825	1	0.5225	1
3	0.6000	1	0.5125	1
3	0.5750	1	0.5300	1
3	0.6000	1	0.5275	1
4	0.6750	1	0.6500	1
4	0.7500	1	0.4125	0
4	0.7250	1	0.5000	1
4	0.6625	1	0.5125	1
4	0.6250	1	0.5000	1
4	0.6500	1	0.4875	1
4	0.6675	1	0.6125	1
4	0.7125	1	0.6675	1
4	0.6750	1	0.4375	0
6	0.5400	1	0.2875	0
6	0.7425	1	0.3725	0
6	0.9425	0	0.4400	0
6	0.9975	0	0.4025	0
6	0.9975	0	0.2475	0
6	0.9950	0	0.0050	0
9	0.8725	0	0.6125	1
9	0.7475	1	0.6025	1
9	0.6925	1	0.5875	1
9	0.7025	1	0.6100	1
9	0.7125	1	0.6100	1
9	0.7025	1	0.6000	1
10	0.7925	0	0.7375	1
10	0.8250	0	0.6850	1
10	0.7500	1	0.6375	1
10	0.8075	0	0.7425	1
12	0.8750	0	0.5000	1
12	0.9250	0	0.4825	1
12	0.8750	0	0.0725	0
12	0.8125	0	0.1925	0
12	0.7250	1	0.0025	0
12	0.7475	1	0.2000	0
12	0.8125	0	0	0

PAIR	ODD FO	DODD	EVEN FO	DEVEN
12	0.8600	0	0.0850	0
12	0.9425	0	0.0850	0
13	0.8725	0	0.3150	0
13	0.7125	1	0.3200	0
13	0.7750	1	0.2975	0
13	0.7500	1	0.0275	0
13	0.6750	1	0.2425	0
13	0.6750	1	0.2925	0
13	0.6750	1	0.6425	1
13	0.8000	0	0.6350	1
14	0.8500	0	0.1275	0
14	0.8750	0	0.1275	0
14	0.8625	0	0.6775	1
14	0.9975	0	0.4100	0
14	0.8275	0	0.4400	0
15	0.7625	1	0.4425	0
15	0.8625	0	0.3675	0
15	0.8500	0	0.4550	0
15	0.9000	0	0.2100	0
18	0.6250	1	0.6250	1
18	0.6250	1	0.5575	1
18	0.6250	1	0.4625	0
20	0.8500	0	0.8225	1
20	0.9750	0	0.8175	1
20	0.8000	0	0.7800	1
20	0.8250	0	0.6750	1
20	0.7250	1	0.6500	1
20	0.7150	1	0.3875	0
20	0.7375	1	0.6800	1
20	0.8250	0	0.4425	0
21	0.6375	1	0.3600	0
21	0.6450	1	0.3400	0
21	0.6550	1	0.3275	0
21	0.6625	1	0.4500	0
21	0.6875	1	0.5000	1
22	0.5625	1	0	0
22	0.7500	1	0.0250	0
22	0.6875	1	0.0250	0
22	0.8125	0	0.2975	0
22	0.8125	0	0.5150	1
24	0.5750	1	0.3125	0
24	0.7500	1	0.4500	0
24	0.5625	1	0.3125	0

Actual and Risk Neutral Offers for Tri-Offer Arbitration
(DODD, DEVEN = 1 if risk averse)

CASE	PAIR	FF	ODD FO	ODD RN	DODD	EVEN FO	EVEN RN	DEVEN
1	26	0.6700	0.5500	0.5129	0	0.2500	0.3799	0
1	12	0.6500	0.5875	0.5065	0	0.5225	0.3759	1
1	11	0.9800	0.7125	0.7578	1	0.4000	0.4676	0
1	11	0.7325	0.6875	0.7084	1	0.1125	0.4616	0
1	26	0.7100	0.5625	0.7075	1	0.1250	0.4613	0
1	25	0.7150	0.4000	0.7076	1	0.2000	0.4613	0
1	25	0.6675	0.6500	0.5128	0	0.3000	0.3798	0
1	2	0.5350	0.2250	0.4451	1	0.2500	0.3349	0
1	2	0.5150	0.4375	0.4311	0	0.4400	0.3248	1
1	2	0.8025	0.5750	0.7195	1	0.2875	0.4634	0
1	2	0.7000	0.5750	0.5195	0	0.3625	0.3838	0
1	2	0.7900	0.7125	0.7169	1	0.5250	0.4630	1
1	2	0.5550	0.5000	0.4584	0	0.4375	0.3442	1
1	11	0.8425	0.7250	0.7287	1	0.2500	0.4648	0
1	19	0.6475	0.6000	0.5064	0	0.5150	0.3758	1
1	13	0.6400	0.4375	0.5036	1	0.4325	0.3740	1
1	12	0.6675	0.5300	0.5128	0	0.5225	0.3798	1
1	10	0.8000	0.6750	0.7190	1	0.4975	0.4633	1
1	13	0.6525	0.6250	0.5082	0	0.4950	0.3769	1
1	13	0.7900	0.5625	0.7169	1	0.3875	0.4630	0
1	13	0.7300	0.5000	0.7083	1	0.4625	0.4615	1
1	5	0.8075	0.6250	0.7206	1	0.6375	0.4636	1
1	13	0.5950	0.5225	0.4823	0	0.4375	0.3603	1
1	12	0.6800	0.6250	0.5160	0	0.5225	0.3817	1
1	12	0.7925	0.6000	0.7174	1	0.5225	0.4631	1
1	12	0.7275	0.6625	0.7081	1	0.5225	0.4614	1
1	9	0.7850	0.3750	0.7159	1	0.3800	0.4628	0
1	9	0.6400	0.3900	0.5036	1	0.3625	0.3740	0
1	9	0.6700	0.3800	0.5129	1	0.3250	0.3799	0
1	10	0.7875	0.6750	0.7164	1	0.2500	0.4629	0
1	12	0.8225	0.6250	0.7240	1	0.5300	0.4641	1
2	4	0.4600	1	0.7870	0	0.4625	0.4616	1
2	4	0.7900	1	0.9562	0	0.7925	0.8605	0
2	3	0.3725	0.6250	0.7841	1	0.5000	0.5136	0
2	1	0.4100	0.6575	0.7852	1	0.4725	0.5219	0
2	1	0.4875	0.7450	0.7878	1	0.5650	0.5380	1
2	1	0.3750	0.6950	0.7842	1	0.4225	0.5137	0
2	27	0.5450	1	0.7887	0	0.5750	0.5425	1
2	22	0.4500	0.7500	0.7867	1	0.6725	0.5310	1
2	21	0.6025	0.8850	0.8742	0	0.6500	0.7436	0
2	15	0.6275	0.8300	0.8807	1	0.6900	0.7539	0
2	13	0.3750	0.5625	0.7842	1	0.4375	0.5137	0
3	11	0.4000	0.6875	0.7873	1	0.2500	0.3018	0
3	10	0.4875	0.7125	0.7821	1	0.3000	0.3637	0
3	10	0.6625	0.7500	0.8293	1	0.2500	0.4502	0
3	8	0.5125	0.6475	0.7841	1	0.5100	0.3796	1
3	12	0.6225	0.6500	0.8120	1	0	0.4361	0
3	12	0.6400	0.6875	0.8191	1	0.5225	0.4427	1
3	12	0.6375	0.7000	0.8181	1	0.5225	0.4418	1
3	8	0.5075	0.6125	0.7836	1	0	0.3765	0
3	8	0.3350	0.7475	0.8024	1	0	0.2507	0
3	7	0.6700	0.9125	0.8329	0	0.5000	0.4524	1

CASE	PAIR	FF	ODDFO	ODDRN	DODD	EVENFO	EVENRN	DEVEN
3	11	0.5875	0.7750	0.7998	1	0.2500	0.4207	0
3	4	0.5125	1	0.7841	0	0.4625	0.3796	1
3	4	0.7100	1	0.8514	0	0.6250	0.4619	1
3	4	0.9075	1	0.9932	0	0.5000	0.4498	1
3	3	0.5575	0.7575	0.7918	1	0.5000	0.4055	1
3	11	0.5400	0.7500	0.7882	1	0.1050	0.3958	0
3	17	0.4675	0.8750	0.7817	0	0.4400	0.3504	1
3	3	0.5600	0.7125	0.7924	1	0.5025	0.4069	1
3	20	0.6125	0.9375	0.8082	0	0	0.4320	0
3	20	0.8675	0.8750	0.9616	1	0.5000	0.4595	1
3	20	0.6625	0.8125	0.8293	1	0.3000	0.4502	0
3	11	0.6825	0.7750	0.8392	1	0.3300	0.4558	0
3	21	0.6375	1	0.8181	0	0.4925	0.4418	1
3	11	0.6950	0.7125	0.8458	1	0.2500	0.4587	0
3	22	0.6875	0.7800	0.8418	1	0.6750	0.4570	1
3	22	0.8000	0.9025	0.9117	1	0.7225	0.4679	1
3	24	0.5175	1	0.7847	0	0.5125	0.3826	1
3	24	0.6625	1	0.8293	0	0.5750	0.4502	1
3	24	0.8800	1	0.9713	0	0.5625	0.4568	1
3	24	0.6075	1	0.8064	0	0.5000	0.4298	1
3	24	0.6800	1	0.8379	0	0.5625	0.4551	1
3	2	0.5375	0.5750	0.7878	1	0.4375	0.3944	1
3	25	0.7000	0.8250	0.8486	1	0.2500	0.4598	0
3	1	0.5000	0.7000	0.7829	1	0.4925	0.3718	1
3	1	0.6650	0.7950	0.8305	1	0.5750	0.4509	1
3	1	0.5075	0.6200	0.7836	1	0.4925	0.4502	1
3	26	0.6300	0.6500	0.8149	1	0.3750	0.4390	0
3	26	0.4500	0.5000	0.7821	1	0.4000	0.3383	1
3	11	0.5950	0.7000	0.8022	1	0.4000	0.4242	0
3	27	0.8725	0.8750	0.9655	1	0.5750	0.4585	1
3	28	0.7550	0.9975	0.8814	0	0.2000	0.4674	0
3	28	0.7200	0.9975	0.8599	0	0.2000	0.4635	0
3	28	0.6075	0.9975	0.8064	0	0.3050	0.4298	0

Note:
Case 1: yb less than ya less than yff.
Case 2: yff less than yb less than ya.
Case 3: yb less than yff less than ya.