



The relationship between uncertainty, the contract zone, and efficiency in a bargaining experiment

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Abstract

Research on bargaining suggests that the efficiency of bargaining is related to the size of the surplus to be divided and to uncertainty about the opponent. We conducted a bargaining experiment which manipulated both of these factors. We find that the presence of uncertainty decreases bargaining efficiency, while the effect of contract zone size depends on whether there is uncertainty or certainty.

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1. Introduction

Economic analyses of bargaining make use of the concept of a ‘contract zone’ —the range of settlement values which make both sides better off than not settling. The two critical attributes of the contract zone are the reservation values of the parties and their knowledge of their opponents’ values. Although previous

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research has examined the effect of each of these factors on bargaining efficiency, no research has systematically examined the combined effect of contract zone magnitude and information. Such an analysis is important because the effect of the contract zone size is likely to depend on the presence or absence of uncertainty which in turn affects the types of bargaining tactics that are available to the parties.

The interactive fashion in which uncertainty and the size of the contract zone influence the efficiency of bargaining has important ramifications. Bargaining typically occurs in the context of institutions which specify a wide variety of rules regarding the dispute resolution process. These institutions include the court system, the National Labor Relations Board and the State Employment Relations Commissions. The rules and guidelines developed by these institutions affect the degree of uncertainty and the size of the contract zone and, consequently, the efficiency of bargaining. Thus, for example, Stevens (1966) argued that final offer arbitration is riskier than conventional arbitration, and should therefore produce larger contract zones and higher settlement rates.¹ This argument persuaded many state governments to adopt final offer arbitration as a means of resolving contract disputes. The results presented below support Stevens' assertion, when final offer arbitration occurs in environments where both sides are uncertain of the other's reservation price. However, when both sides are knowledgeable about their opponent's reservation price, interventions designed to expand the contract zone may interfere with efficiency. In short, the contract zone magnitude and bargainers' knowledge of their opponents' reservation prices influence bargaining strategies and outcomes interactively. To predict the impact of institutions that influence one of these factors, it is necessary to take account of the other.

Crawford (1982) has suggested that, when there is certainty about the opponent's reservation value, the parties may be more likely to commit to incompatible positions that preclude settlement when the contract zone is large than when it is small. This occurs because the relative costs and benefits of commitment can make commitment more likely when there are large contract zones. Thus, when bargainers know one-another's reservation prices, one could expect a negative relationship between contract zone size and efficiency.

When, however, there is uncertainty about the parties' reservation values, Cramton (1992) shows that bargainers will make or delay offers to convey information about one's reservation price. He shows that strategic delay in making offers should be less likely the larger the contract zone, since bargainers expecting large surpluses from a negotiation are more impatient than bargainers expecting small surpluses. This means that there would be a positive relationship between contract zone size and efficiency, under uncertainty.

¹ However, Farber and Bazerman (1989) show that under certain assumptions about the form of agents' utility functions, final offer arbitration has smaller contract zones than conventional arbitration.

2. Previous literature

Crawford's model (1982) is a formalization of the bargaining process described by Schelling (1963) in which negotiators attempt to credibly commit themselves to advantageous bargaining positions. Under specific conditions, it predicts a negative relationship between the contract zone and efficiency. The intuition behind this result is that when the parties know each others' reservation values, larger contract zones can promote impasses by offering more surplus to fight over. Bargainers may stake out increasingly extreme positions when the contract zone increases, thereby making impasses more likely. Bloom (1981) argues that if the bargainers know the location of the contract zone (they know each other's reservation values) and if large contract zones cause settlement expectations to diverge to a greater extent than small ones, the likelihood of disagreement will increase with the magnitude of the contract zone.

Whereas the predictions just discussed derive from theoretical analysis, Malouf and Roth (1981) provide *experimental* evidence about the relationship between time to settlement and contract zone size under perfect certainty.² In their experiments, bargainers negotiated over the division of lottery tickets³ where contract zone size was manipulated by placing constraints on the maximum share of the tickets that each player could receive. Since there was complete information about how the lottery tickets could be divided, there was no uncertainty about the magnitude or location of the contract zone. The negotiators were given eight minutes to reach an agreement, and no penalties were imposed on bargainers for settling later versus earlier within the eight minutes. They found that time to settlement increased with the size of the contract zone.

When there is uncertainty about the opponent's reservation value and the parties face costs to delaying an agreement, those expecting larger gains from trade will make concessions earlier than those expecting smaller gains from trade (Cramton, 1992). Since increasing the size of the contract zone increases the gains from trade, Cramton's model predicts that both parties will make concessions more rapidly when the contract zone is larger, and thus efficiency will be related positively to the magnitude of the contract zone.

Tracy's bargaining model (Tracy, 1986, Tracy, 1987) predicts that under uncertainty, increases in the size of the contract zone decrease the probability and duration of a strike (increase bargaining efficiency). His empirical results using

² The purpose of their paper, however, was not to study the effect of the contract zone on disagreement, but to study the effect of Axelrod's (Axelrod, 1967) measure of conflict of interest on disagreement. However, in their experimental design, Axelrod's measure and the size of the contract zone are perfectly positively correlated.

³ Malouf and Roth use lottery tickets rather than dollar payoffs because their paper tests predictions of game-theoretic models which require risk neutrality.

data on U.S. contract negotiations suggest that strike duration is negatively related (weakly) to the firm's rate of return on its stock.

In an experimental study, Ashenfelter et al. (1992) examined negotiations where disputes were resolved via arbitration. They found that as uncertainty about arbitration increased, dispute rates decreased. If bargainers are risk averse, increases in uncertainty about the arbitrator increase the effective magnitude of the contract zone, so that these findings are consistent with the hypothesis that under uncertainty, increases in the contract zone increase efficiency.

The combination of all these studies suggests that bargaining environments under certainty or uncertainty about the opponent differ considerably. When agents are uncertain about the payoffs of opponents, bargainers with more gains to trade will be able to settle faster. Searching for settlements may be more difficult when gains to trade are smaller. However, when there is certainty, bargainers with larger contract zones may reach settlements more slowly. If bargainers attribute an ungenerous offer to greediness on the part of their opponent, this may hinder the bargaining process and cause longer times to settlement. This effect may be magnified under large contract zones since one party would be receiving a very large payoff relative to the other party.

The net result is that the effect of an increase in the size of the contract zone will depend on the information available to the bargainers. Under certainty, an increase in the contract zone will increase time to settlement whereas under uncertainty, an increase in the size of the contract zone will decrease time to settlement. In the next section we describe our experiment which examines these hypotheses.

3. Experimental design and method

Testing the relationship between uncertainty, the size of the contract zone and bargaining efficiency using field data is difficult. With field data, the size of the contract zone and uncertainty are never measured directly, and therefore empirical analysis must rely on proxy variables which are thought to be correlated with these factors. To avoid this problem, we conducted a bargaining experiment in which the two central variables of interest were manipulated systematically. Although experiments are simplifications of actual bargaining environments, the possibility for control and measurement provides offsetting advantages.

3.1. Experimental design

Subjects played the role of manager and worker in a bargaining scenario where the worker negotiates with the manager over the wage. The maximum wage the manager would offer is Y_m , and the minimum wage the worker would accept is Y_w . Bargainers were allowed 10 minutes to negotiate. Costs were assessed on the

Table 1
Experimental design

	Certainty	Uncertainty
Small contract zone	Condition SC	Condition SU
Large contract zone	Condition LC	Condition LU

parties every minute in which they did not reach a settlement. We designed the experiment to give the bargainers enough time to settle so that their outcomes would not be censored.⁴

Let C_m and C_w be the fixed costs for failure to settle after each minute of bargaining. The total cost for delay after n minutes is $n \cdot C_m$ for the manager and $n \cdot C_w$ for the worker. If they settle at Y after n minutes, the gain to the manager from the negotiation is $(Y_m - Y - n \cdot C_m)$ and the gain to the worker is $(Y - Y_w - n \cdot C_w)$. The costs to delay are common knowledge.

The experiment is a 2×2 design. The manipulated variables are the size of the contract zone and whether bargainers know their opponents' reservation values. The design is illustrated in Table 1.

The size of the contract zone was manipulated by varying Y_m and Y_w . These values were determined by a draw from a rectangular distribution with mass points every 25 cents. In conditions SC and SU (small contract zones), Y_w ranged from \$23 to \$25 and Y_m ranged from \$25 to \$27. In conditions LC and LU (large contract zones), Y_w ranged from \$21 to \$23 and Y_m ranged from \$27 to \$29. Therefore, the average contract zone size is \$2 in the small contract zone conditions and \$6 in the large contract zone conditions. In all conditions, the manager's cost of delay was 15 cents and the worker's cost of delay was 10 cents a minute.

In the certainty conditions (SC and LC) both parties drew their own reservation values from the distribution, and these draws were revealed to the opponent. In the uncertainty conditions (SU and LU), the bargainers only knew their own reservation value and the distribution from which their opponent's reservation value was drawn. Note that the degree of uncertainty about the opponent (the variance of the distribution) was identical across the small and large contract zone conditions.⁵

3.2. Method

Subjects were students and staff members at Carnegie Mellon University who responded to an electronic bulletin board posting advertising the study. Each

⁴ Pretests indicated that 10 minutes would be sufficient for almost all parties to reach an agreement.

⁵ The variance of a rectangular distribution with endpoints a and b is $(a-b)^2/12$. Since the difference between the endpoints in the two uncertainty cases is identical, the measure of uncertainty is the same as well.

subject negotiated only once. The subjects were paid \$4 for participation in the experiment and also received their payoffs from the negotiation. Losses were deducted from subjects' \$4 participation fee so that each subject left with a positive total payoff.

The experiment was conducted in a computer terminal room where participants were paired with one other anonymously and communicated through terminals. After the instructions were read, subjects each drew a number from a cup that had all the possible numbers of their reservation values as managers and workers. The only difference between the certainty case and the uncertainty case was whether or not the drawn number was revealed to the other party. In the certainty case, the subjects were required to type in the true number so that their opponent would know the value. The experimenter checked to see that they had correctly done so. In the uncertainty case, the value drawn remained unknown to the opponent.

3.3. Outcome measures

Our objective is to examine how bargaining efficiency is affected by uncertainty and the size of the contract zone. Two measures of efficiency have been used in previous research: time to agreement and dispute rates. Because our pre-tests indicated that allowing the bargainers 10 minutes to negotiate would be sufficient for most pairs to reach an agreement, we are able to use time to settlement as one measure of efficiency. Because negotiation is costly, efficiency will be decreasing in time to settlement. We will also examine a second measure of efficiency —the percent of the contract zone which the parties receive, which will be less than 100 if delay costs are imposed on the bargainers.

4. Experimental results

To obtain a qualitative sense of the data, we plot the distributions of time to settlement for the four conditions in Fig. 1. The mean and median time to settlement in each condition are shown in Table 2. Paralleling the results from Malouf and Roth (1981), when there is certainty, it takes longer, on average, for the bargainers to settle when there are larger contract zones. In contrast, when there is uncertainty, larger contract zones lead to shorter settlement times.

Table 3 investigates how the experimental manipulations affected bargaining efficiency using two measures: time to settlement and percent of the contract zone obtained by the bargainers.⁶ Bargaining efficiency is negatively correlated with the time to settlement and positively correlated with share of contract zone

⁶ A regression using the rank of settlement was also estimated (where rank is the pair's ranking (1 to 80) of settlement time). This regression produced findings similar to those presented in Table 3.

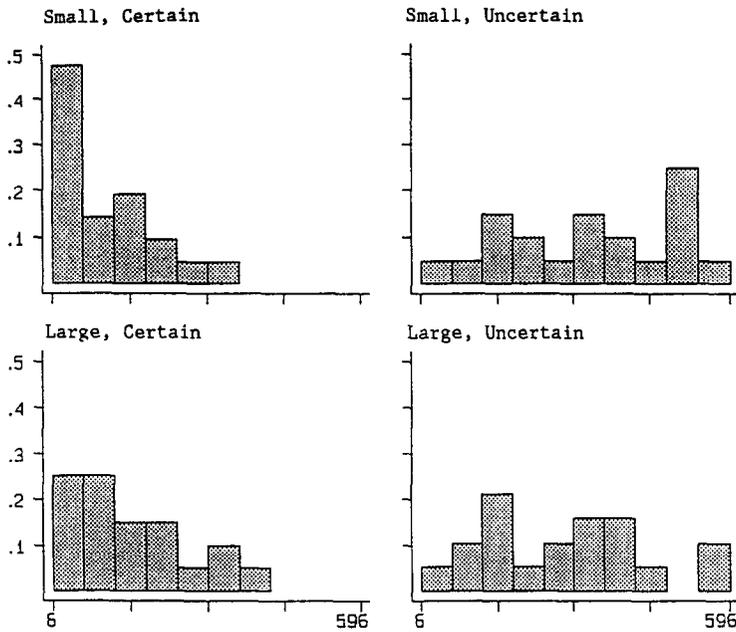


Fig. 1. Histograms by conditions.

received. The main effects of contract zone size and information and the interaction between them are used as independent variables. Large is a dummy variable for large contract zone, certainty is a dummy variable for the certainty condition.

The results show no significant main effect for contract zone size ($p = 0.207$) for the first regression, but a significant effect for the second regression ($p <$

Table 2
Mean and median settlement time by condition, all bargaining pairs

	Certainty	Uncertainty
<i>Mean</i>		
Small contract zone	107.5 ^a (19.2)	329.3 ^b (37.4)
Large contract zone	150 ^a (25.0)	274.6 ^b (35.9)
<i>Median</i>		
Small contract zone	81.0	336.0
Large contract zone	127.5	264.0

Standard errors are in parentheses. The number of bargaining pairs in each condition is 21, 20, 20, 19 (SC, LC, SU, LU). Means which do not share a common subscript are significantly different from each other at the 0.01 level.

Table 3

Regression analysis, time to settlement and percent of contract zone received by pair

	Time to settlement	Percent of contract zone received by pair
Large	-54.721 (42.993)	0.353 *** (0.071)
Certainty	-222.252 *** (41.930)	0.340 *** (0.069)
Large · Certainty	97.673 * (60.055)	-0.246 ** (0.099)
Constant	329.300 *** (30.009)	0.463 *** (0.049)
R^2	0.32	0.38

Standard errors are in parentheses. The sample size is 80. * * * * * indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

0.001). Contract zone size affects the percent of the contract zone received by the bargainers because for any given settlement time, the costs to delay are a smaller proportion of the total size of the contract zone in the large contract zone conditions.

The main effect for certainty indicates that bargainers are able to settle more quickly when there is certainty rather than uncertainty, regardless of the size of the contract zone ($p < 0.001$ for both regressions). The coefficient on the interaction is marginally significant for the first regression ($p = 0.108$) and significantly different from zero for the second regression ($p = 0.015$). The results suggest that the way in which the size of the contract zone affects the dependent variables depends on the presence or absence of uncertainty. Thus, our main hypotheses are confirmed.

Based only on the regressions in Table 3, it is difficult to draw strong conclusions about the underlying causes of delayed settlements. To understand why settlement times differed across the conditions, we analyzed the verbal communication of the subjects. A research assistant who was blind to the condition and hypotheses evaluated the transcripts from the negotiation session to code the presence of strategies we thought might be important causes of bargaining impasse. Three strategies we focused on are: whether at least one of the bargainers exaggerated their reservation price (EXAGGERATION), suggestions by the bargainers to 'split the contract zone' (SPLIT), and bargaining proposals that were backed by claims of fairness (FAIR). Each of these variables is coded as a 'one' if the tactic is used by the bargainers and a zero if the tactic is not used. Each tactic was coded separately, which allows the possibility that a single negotiation session will be coded as employing multiple strategies.

Table 4
Strategies by condition

	Certainty	Uncertainty
<i>Exaggeration of one's reservation value — EXAGGERATION</i>		
Small contract zone	0	0.35
Large contract zone	0.05	0
<i>Splitting the contract zone — SPLIT</i>		
Small contract zone	0.33	0.05
Large contract zone	0.55	0.15
<i>Appeals to fairness — FAIR</i>		
Small contract zone	0.48	0.25
Large contract zone	0.60	0.45

If the strategy was used, it was coded as a one and coded as a zero if not used in the negotiations. The significance values for the chi-square tests for differences across conditions are, respectively: 0, 0.002, and 0.164.

The use of these strategies summarized by condition are presented in Table 4. Exaggeration of one's reservation value occurs in 35% of the negotiations with a small contract zone and uncertainty, and virtually never in the other conditions. Consistent with Cramton (1992), when there is uncertainty and the contract zone is

Table 5
Regression analysis, time to settlement and percent of contract zone received by pair

	Time to settlement	Percent of contract zone received by pair
Large	-53.194 (47.576)	0.388 *** (0.077)
Certainty	-204.556 *** (47.440)	0.343 *** (0.076)
Large · Certainty	106.858 * (64.345)	-0.306 *** (0.104)
Exaggeration	19.496 (57.001)	0.065 (0.092)
Split	-93.143 ** (49.585)	0.186 ** (0.080)
Fair	68.606 * (41.709)	-0.144 ** (0.067)
Constant	309.982 *** (37.255)	0.467 *** (0.060)
R ²	0.36	0.44

Standard errors are in parentheses. The sample size is 80. *, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

small, bargainers are more patient and may engage in strategic behavior which could delay a settlement. However, when there is uncertainty and the contract zone is large, bargainers are impatient and settle quickly.

The second panel of Table 4 suggests that offers to split the contract zone are more likely when there is certainty about the contract zone and when the contract zone is larger. It is easier to suggest a split of the total surplus when the amount to be divided is known, as in the certainty conditions. In the third panel of Table 4, the pattern of appeals to fairness is similar to that for the 'split' strategy. It is easier to appeal to notions of fairness when the contract zone is known, and 'fair' solutions may be more acceptable to the bargainers where there are larger contract zones.

The presence of the three strategies are included as explanatory variables in the regressions of the two measures of bargaining efficiency in Table 5. The results suggest that the SPLIT and FAIR strategies are related to the two dependent variables, once the experimental main effects and interaction are controlled for. Use of the SPLIT strategy decreases time to settlement and increases the share of the contract zone the pair receives ($p = 0.064, 0.023$). Use of the FAIR strategy increases time to settlement and decreases the percent of the contract zone the pair receives ($p = 0.104, 0.036$). Misrepresentation of reservation values does not affect either dependent variable. Once the strategies are included, the coefficients on the main effects and interaction are not significantly affected, indicating that the strategies were not strong mediators.

5. Conclusion

Our experimental study helps to clarify the relationship between the size of the contract zone, uncertainty, and the efficiency of bargaining. We find that, controlling for the size of the contract zone, uncertainty about the location of the contract zone leads to less efficient bargaining than certainty. We also find that the efficiency of bargaining may not necessarily increase with an increase in the contract zone. The sign of this relationship appears to depend on whether or not there is uncertainty about the location and size of the contract zone. When there is uncertainty about one's opponent, an increase in the size of the contract zone will lead to more efficient bargaining, whereas under certainty about one's opponent, an increase in the size of the contract zone will lead to less efficient bargaining.

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