Threat and Commitment in Adversarial Bargaining: Experimental Evidence

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October 10, 2022

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Abstract

We experimentally study pre-commitment power's role in credible threatening in adversarial bargaining. A proposer demands payment from the responder, and if the responder rejects to pay, a conflict starts. Before the proposer makes the demand, she chooses the intensity of the conflict. A higher intensity makes both players worse off. The proposer is only partially committed to the intensity; if the conflict starts, she can reduce the intensity up to a fraction of it. In equilibrium, the proposer gains bargaining power by choosing an overly large intensity, which puts both players in a position of having a loss if the conflict starts. The data are qualitatively consistent with the theory. If pre-commitment power allows it, subjects choose a high intensity and tie their hands for the conflict. However, they chose a lower intensity than predicted. Although they gain bargaining power, it is not reflected in the payment they demand from the responder.

Keywords: C78, C92, D74

JEL Codes: Adversarial bargaining, credible threats, conflict, experiments

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1 Introduction

Being able to credible commit to a threat increases bargaining power. In adversarial bargaining, a participant can extract a higher surplus if she can take a public action that, if there is no agreement, will cause a significant loss to their opponents. For example, a prosecutor overcharges the defendant before plea bargaining to gain bargaining power. Filing several charges is a threat that induces the defendant to accept a severe plea deal to avoid going to trial and face substantial changes.

However, the threat is credible only if the proposer will not scale it down once the conflict starts. In the above example, if the prosecutor and defendant know that the charges are tough to prove, the prosecutor will likely have a reputation cost at trial if losing the case. Therefore, the proposer might refer to backing down the severe charges.

What makes a threat credible is that the action of scaling down the threat is also costly. The prosecutor might also have a reputation cost at the District Attorney's office by dropping charges once filled, which might affect her future career. If those costs are higher than the cost of losing at trial, then the threat is credible.

We present a one-period version of the adversarial bargaining model in Cuellar and Rentschler (2022). The theoretical prediction is that the proposer uses an exogenous imperfect pre-commitment device (for example, the reputation cost of scaling down the charges in the above example) to credible commit to a threat that maximizes the responder's loss. The threat is risky; the proposer also gets a significant loss if an agreement is not reached.

We run an experiment in the lab to test whether the proposer uses the commitment power to credible commit to a threat that puts the responder in a risky position, but also a dangerous position for the proposer. And second, whether that is translated to a higher payoff than under the absence of commitment power.

The experimental results qualitatively confirm the theory predictions; the proposer commits to a high threat and puts herself in a bad position. However, the threat is not as high as theoretically predicted. Furthermore, the results show that, although the proposer can commit to a credible final threat, it does not translate into a higher payoff.

We present an adversarial bargaining model with two stages: negotiation and resolution. In the resolution stage, the proposer chooses a threat and then makes an offer to the responder. If the responder accepts it, the game ends. If the offer is rejected, the resolution stage starts. Before the payoffs are realized, the proposer can scale down its threat up to an exogenous point, which we refer to as the pre-commitment power. After the proposer scales down the threat, the payoff is realized as a function of the final threat. The responder loss is maximized at a higher threat than the proposer payoff is maximized at the resolution stage.

In equilibrium, if the proposer has a high enough pre-commitment power, the proposer chooses a high threat to tie her hands at the resolution stage, and credible threatens the responder to an optimal scaled-down threat at the resolution stage. Doing so, she puts herself in a position where she gets a loss if the resolution stage is reached. The proposer makes an offer equal to the maximum responder loss at the resolution stage, and the responder accepts it. In equilibrium, the resolution stage never is reached.

The experiment closely follows the model. We use two levels of commitment: high and low. With the high commitment, the proposer can overstate the threat to being able to credible commit to the optimal scaled-down threat. However, with the low commitment level, the proposer cannot credibly commit to an optimal scaled-down threat, and any threat is essentially cheap talk.

In the experiment, more than half of the offers are rejected, providing an excellent framework for studying how they behave in the predicted off-path equilibrium. The first main result shows the theoretical prediction that the proposer uses the commitment to credible commit to a higher final threat than the one she would have chosen without the commitment. Comparing the treatments with different levels of commitment, the proposer chooses a lower initial threat with high commitment, and proportionally to what is possible, they scaled it down more than with lower commitment. Nevertheless, the final threat is higher for the high-commitment treatments.

Although the proposer ties her hand, the subjects are more conservative in threatening than predicted. The proposer chooses a lower initial threat than predicted for the high-commitment treatments, which implies that the responder's expected loss is lower than expected and the proposer's expected payoff is not as bad as predicted if the resolution stage starts.

The second main result shows that, although the proposer credible threatens the responder with a higher loss if the commitment is high, there is no significant difference between the offers made and the accepted offers. The offers distribution shows no difference for high and low commitment, although the responder's losses are different for different levels of commitment.

Related Literature: The model presented in this article is related to pre-commitment literature in bargaining, which starts with Schelling (1956) and Schelling (1960), who described the bargaining process as an attempt of players to commit themselves to a position, and credible convince the others that conceding is not possible. Early formalization of Schelling's ideas are found in Crawford (1982), who presents a two-period bilateral bargaining model with concessions in the second period, and Muthoo (1992) and Muthoo (1996) who formalize the concession cost, making it proportional to the size of it. Cuellar and Rentschler (2022) present a model of adversarial bargaining in which the commitment is to a threat rather than a demand.

Other papers that include the notion of commitment to a position are: Dutta (2012), Basak and Deb (2020),Basak (2021), Dutta (2021), Miettinen and Perea (2015), Ellingsen and Miettinen (2008), Li (2011), Chung and Wood (2019), Ellingsen and Miettinen (2014), Miettinen and Vanberg (2020), Levenotoğlu and Tarar (2005), and Tarar and Leventoğlu (2009).

The experimental literature that studies commitment in bargaining is slim. Embrey et al. (2015) shows that the predictions of the reputational bargaining literature holds: if there is a probability that that there exists a behavioral type that is fully committed to an offer and never changes it, the rational bargaining imitates him to gain bargaining power. Heggedal et al. (2022) shows that under the presence of outside options, the incentive to imitate the behavioral type is removed and it ensures an immediate agreement whenever two rational bargainers match.[1]

Outline: The plan of the paper is as follows. Section 2 introduces the experimental design and Section 4 the results. Section 5 concludes.

2 Theory and Equilibrium Predictions

2.1 Model

Two players, a proposer (P) and a responder (R) are involved in adversarial bargaining. The game is divided into two stages: bargaining and resolution. The resolution stage starts if they do not reach an agreement during the bargaining, and it is a lottery that assigns a payoff.

In the bargaining stage, the proposer first chooses how much to threaten the responder. The threat represents a position $x^I \in [0, \bar{x}]$, which is a payoff relevant for the lottery in the resolution stage. After choosing the threat, the proposer offers a deal y to the responder. If accepted, the payoffs are:

$$u_P = y, \quad \text{and} \quad u_R = -y,$$

and the game ends. If the deal is rejected, the resolution stage starts.

[1]Reputational bargaining literature starts with Abreu and Gul (2000), who present the canonical mode. Several extensions have been made, among others: Kambe (1999), Abreu and Sethi (2003), Wolitzky (2012), Atakan and Ekmekci (2014), Sanktjohanser (2020), and Ekmekci and Zhang (2021).

The resolution stage has a cost of $k \geq 0$ for both players. Before the payoffs are realized, the proposer has the opportunity to scale down the threat up to a parameter $\alpha \in [0, 1]$. That is, the proposer chooses a final threat $x^F \in [\alpha x^I, x^I]$. Then, a lottery assigns a payoff in the following way:

$$u_R(x^F) = \begin{cases} -x^F & \text{with prob } p(x^F) \\ 0 & \text{with prob } 1 - p(x^F) \end{cases} \quad \text{and} \quad u_P(x^F) = \begin{cases} \phi x^F & \text{with prob } p(x^F) \\ -x^F & \text{with prob } 1 - p(x^F). \end{cases}$$

The probability $p(x^F)$that the proposer *wins* at the resolution stage is inversely proportional to the threat:

$$p(x^T) = \frac{\bar{x} - x^T}{\bar{x}},$$

and the parameter $\phi \geq 1$ represents how extra valuable is for the proposer to win in the resolution stage compared to losing on it.[2]

We restrict our attention to parameters ϕ such that the proposer's expected payoff $\mathbb{E}u_P(x^F)$ is not higher than the responder's expected loss $-\mathbb{E}u_R(x^F)$ for any $x^F \in [0, \bar{x}]$. Figure 1 shows a representation of the expected payoff and loss.

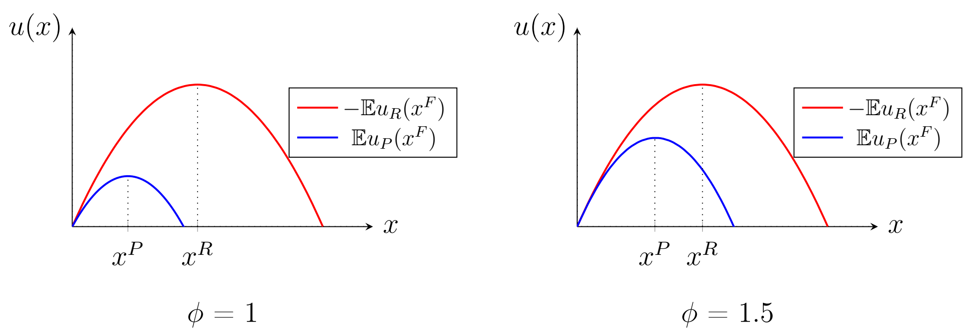


Figure 1: Equilibrium initial threat and offer.

As Figure 1 shows, the maximizers of both functions are not the same. Define x^P as the maximizer of $\mathbb{E}u_P(x)$ and x^R as the maximizer of $-\mathbb{E}u_R(x)$. The proposer's trade-off is captured by $x^P < x^R$; the proposer would like to threaten the responder with x^P, but it is not sequentially rational to keep $x^F = x^P$ if the resolution stage starts.

The timeline of the game is represented in Figure 2.

[2]Without loss of generality, we consider that the value that the proposer wins or losses is equal to the final threat x^F.

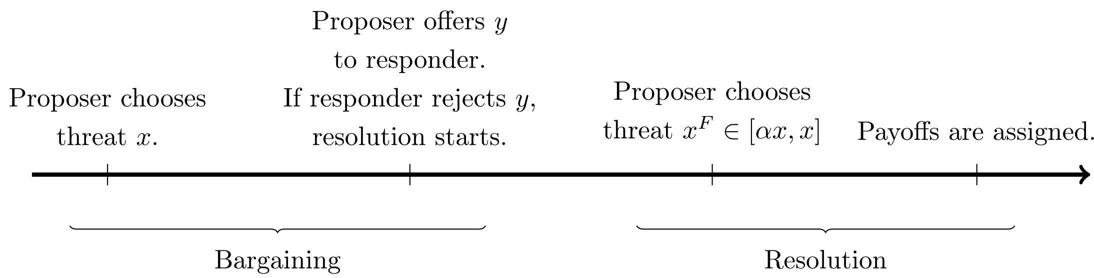


Figure 2: Timeline of the game

2.2 Equilibrium Behavior

The main insight is that a rational proposer chooses a larger threat as lower is the parameter α. The parameter α represents the proposer's commitment power, as the proposer can only scale down the threat to αx at the resolution stage.

If the proposer chooses a threat $x > x^P$, she will choose $x^F = \max\{x^P, \alpha x\}$ in case the responder rejects the offer, to maximize her expected payoff given the self imposed restriction $x^F \in [\alpha x, x]$. The responder accepts the deal y if $y \leq -\mathbb{E}u_R(x^F)$. Therefore, the optimal value of the deal that the responder accepts is given by the election of x and the commitment. Consider the following cutoffs:

$$\underline{\alpha} = \frac{x^P}{\bar{x}} \quad \text{and} \quad \bar{\alpha} = \frac{x^R}{\bar{x}},$$

in which $\bar{\alpha} > \underline{\alpha}$.

High commitment level: If the commitment level is high ($\alpha \geq \bar{\alpha}$), the proposer chooses $x = \frac{x^R}{\alpha}$, and offers $y = -\mathbb{E}u_R(x^R)$, as the final threat will be $x^F = \alpha\frac{x^R}{\alpha} = x^R$ if the deal is rejected. In equilibrium, the responder accepts the deal, and the payoffs are:

$$u_P = -\mathbb{E}u_R(x^R) \quad \text{and} \quad u_R = \mathbb{E}u_R(x^R).$$

For the experimental setting, the analysis of the off-path equilibrium is relevant. On it, the proposer chooses $x^F = x^R$, and the responder gets the same (expected) payoff as accepting the deal. However, the proposer gets a lower payoff, which can also be negative as in Figure 1. In other words, the proposer *ties her hands* when choosing the initial threat as a way to induce the responder to accept a high deal.

Note that the initial threat is decreasing in α, that is, the proposer chooses a higher threat as complement of the lack of perfect commitment power.

Intermediate commitment level: If the commitment level takes an intermediate value ($\underline{\alpha} \leq \alpha < \bar{\alpha}$), the proposer chooses $x = \bar{x}$, and offers $y = -\mathbb{E}u_R(\alpha\bar{x})$. Given that $\alpha\bar{x} < x^R$ for any $\alpha < \bar{\alpha}$, the best the proposer can do is to choose $\bar{x}$. In equilibrium, the proposer offers $y = -\mathbb{E}u_R(\alpha\bar{x})$ and the responder accepts it. Payoffs are:

$$u_P = -\mathbb{E}u_R(\alpha\bar{x}) \quad \text{and} \quad u_R = \mathbb{E}u_R(\alpha\bar{x}).$$

In the off-path equilibrium, if the responder rejects the offer, the responder gets the same expected payoff as the deal, and the proposer gets a lower payoff. Note that in this case the proposer gets a decreasing expected payoff in α. Still the proposer ties her hand, but is a lower degree than if α is high.

Low commitment level: If the commitment level is low ($\alpha < \underline{\alpha}$), the proposer chooses any $x \in [x^P, \bar{x}]$, and offers $y = -\mathbb{E}u_R(x^P)$. In this case, $\alpha\bar{x} < x^P$, that is, even by choosing the highest possible threat, the proposer will choose the threat that maximizes her expected payoff instead of the responder's loss. Choosing $x < x^P$ is not optimal, as the proposer would like to increase the threat at the resolution stage.

In equilibrium, the proposer offers $y = -\mathbb{E}u_R(x^P)$, and the responder accepts it. In the off-path equilibrium, the proposer chooses $x^F = x^P$ and gets the highest possible amount at the resolution stage.

In this case, we say the proposer engages in *bluffing* if $x > x^P$, as she cannot sustain that position in equilibrium.

Summary: In equilibrium, the election of the initial threat and the optimal deal to be offered are:

$$x(\alpha) = \begin{cases} [x^P, \bar{x}] & \text{if } \alpha \in [0, \underline{\alpha}] \\ \bar{x} & \text{if } \alpha \in (\underline{\alpha}, \bar{\alpha}] \\ \frac{x^R}{\alpha} & \text{if } \alpha \in (\bar{\alpha}, 1] \end{cases} \quad \text{and} \quad y(\alpha) = \begin{cases} -\mathbb{E}u_R(x^P) & \text{if } \alpha \in [0, \tilde{\alpha}] \\ -\mathbb{E}u_R(\alpha\bar{x}) & \text{if } \alpha \in (\tilde{\alpha}, \bar{\alpha}] \\ -\mathbb{E}u_R(x^R) & \text{if } \alpha \in (\bar{\alpha}, 1], \end{cases}$$

and the responder accepts the offer. Figure 3 graphically shows the initial position and payoff as a function of the commitment level.

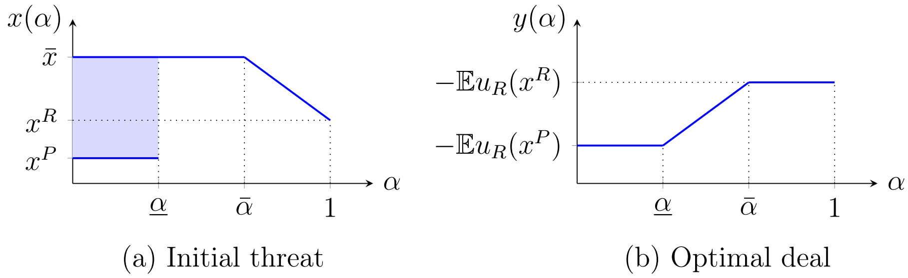


Figure 3: Equilibrium initial threat and offer.

The equilibrium predictions consider the players follow the equilibrium path. In that scenario, the resolution stage is never played. However, if there is a deviation of the equilibrium path in which the responder rejects the deal y, the final threat the proposer chooses is $x^F = x$ if $x \leq x^P$, and $x^F = \max\{x^P, \alpha x\}$ if $x > x^P$.

3 Experimental Design

The experimental design follows the game described in Section 2. The parameters used are $\bar{x} = 100$ and $k = 10$, and the functional form of $p(x^F)$ is

$$p(x^F) = 1 - \frac{x^F}{100}.$$

Four treatments were conducted, corresponding to combinations of two levels of ϕ and two levels of α. We consider $\phi \in \{1, 1.5\}$ and $\alpha \in \{0.2, 0.7\}$. We refer to each combination as:

Treatment	α	ϕ
T1	0.7	1
T2	0.7	1.5
B3	0.2	1
B4	0.2	1.5

We refer to treatments T1 and T2 as *truthful* treatment, as the proposer has enough commitment power to credible threaten the responder with maximizing her loss. And we refer to B3 and B4 as *bluffing* treatment as the proposer does not have commitment power but still can choose a large threat as bluffing.

We are interested in studying the commitment's effect. Therefore, we focus on pairwise comparisons between treatments T1 - B3 and T2 - B4, as the difference between them is the value of α. We consider two values of ϕ to study if the effect of the commitment on the behavior is robust to a more attractive payoff at the resolution stage.

The experiments were conducted in the Experimental Economics Lab at Utah State University using undergraduate students from all majors. The treatments were implemented using a within-subjects design for α and a between-subject design for ϕ. There were 12 sessions, with 10 participants in each one. In six sessions, the parameter ϕ was equal to 1, and the rest was equal to 1.5. In each sessions there were 30 rounds, 15 with $\alpha = 0.7$, and 15 with $\alpha = 0.2$. In six of the sessions, the first 15 rounds were $\alpha = 0.7$, and in the other six, the first 15 rounds were $\alpha = 0.2$.

In each round, subjects were randomly paired. One of each pair was chosen as the proposer and the other as the responder. The proposer first chooses the initial threat $x_I \in [0, 100]$, then the proposer chooses an offer $x \in [0, 100]$. When choosing the offer, the screen shows the proposer the possible values of the final threat if the responder rejects the offer. It allowed the proposer to explore different values by showing the probability of winning and losing at the resolution stage. See Appendix for screenshots. After the offer was made, the proposer decided whether accept or reject it. The responder's screen showed the initial position chosen by the proposer and let the responder explore the possible final threats and associated probabilities in case the offer is rejected. If the responder accepts the offer, the round ends. If not, the proposer chooses the final threat, and the payoffs are realized.

3.1 Key equilibrium predictions

The first important key equilibrium prediction is that the proposer uses the commitment power to credible tie her hands to a high final threat. It implies that the election of the initial threat has to complement the commitment power to credible commit to choose x^R as the final threat for $\alpha = 0.7$ ($0.7 > \bar{\alpha}$).

The second key equilibrium prediction is that the proposer uses that credible threat to induce the responder to accept a large offer if $\alpha = 0.7$. This prediction has two parts. First, the proposer choose to make an appropriate offer (higher than the offer for $\alpha = 0.2$), and second the responder accepts that offer.

Table 1 shows the theoretical prediction for each variable.

4 Results

We drop the first five rounds for each treatment in each session for possible learning effects. Table 2 summarizes the outcomes of the bargaining. On average, more than 50% of the ne-

	T1 (0.7,1)	T2 (0.7,1.5)	B3 (0.2,1)	B4 (0.2,1.5)
Initial threat	71.4	71.4	[25,100]	[30,100]
Offer	35	35	28.7	31
Percentage accepted	1	1	1	1
Final threat	50	50	25	30
Expected payoff proposer	35	35	28.7	31
Expected payoff proposer (off-path)	-10	2.5	2.5	12.5
Expected payoff responder	-35	-35	-28.7	-31

Table 1: Theoretical prediction.

gotiations ends at the resolution stage, which contradicts the theoretical results, but allows the analysis of the realization of final threats. We evaluate the subjects' performance by dividing the analysis into two main results. The first is regarding the use of commitment to tying hands behavior, and the second analyses how it translates to an agreement.

	T1 (0.7,1)	T2 (0.7,1.5)	B3 (0.2,1)	B4 (0.2,1.5)
Mean initial threat	44.8	49.2	65.1	63.8
Mean offer	35.8	39.8	38.1	38.8
Proportion of accepted offers	0.45	0.48	0.44	0.45
Mean final threat	38.3	41	33.9	32.4
Proposer's mean expected payoff (predicted)	-1.1	8.1	2.3	12.0
Proposer's mean expected payoff (realized)	-5.3	4.5	-2.9	8.8
Responder's mean expected payoff (predicted)	-30.8	-31.7	-28.3	-30.4
Responder's mean expected payoff (realized)	-31.5	-32.2	-30.5	-30.5

Table 2: Outcomes of the bargaining

Table 2 shows two expected payoffs for the proposer and the responder. The *predicted* values refer to the calculation of the expected payoff considering that the proposer chooses the optimal final threat, conditional in the initial threat that they decided. The *realized* value refers to the expected payoff at the resolution stage for those players whose offer was rejected, and it is calculated using their chosen final threat.

4.1 Effect of the commitment on the threat

Result 1: *The proposer uses the commitment power to tie her hands and force her to a final threat higher than* x^P.

There is a wide range of initial threats in the four treatments, as shown in Figure 4. The mean initial threat that the proposer chooses in the treatments T1 and T2 are lower than in treatments B3 and B4. The mean initial threats for treatments T1 and T2 are 44.8 and 49.2, respectively, and treatments B3 and B4 are 65.1 and 63.8, respectively. As Figure 4 shows, the distribution of the initial threat is consistent with subjects that understand the role of commitment. For treatments T1 and T2, the proportion of initial threats higher or equal to 95 are 1.7% and 2.3%, while for treatments B3 and B4 are 25% and 15%, respectively.

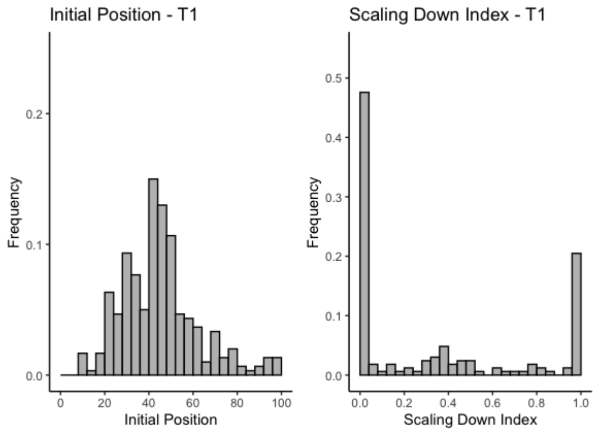
Definition: The scaling down index for subject i is defined as:

$$SDI_i = \frac{x_i^F - \alpha x_i^I}{(1-\alpha)x_i^I}.$$

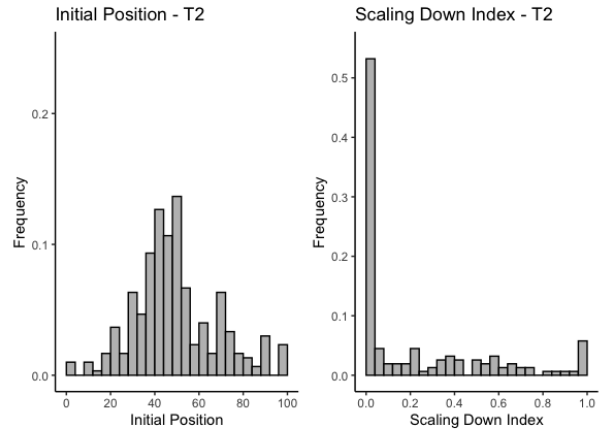
The range of values for the scaling down index is $[0, 1]$. If $SDI_i = 1$ means the proposer did not scaled down the threat, and $x_F = x_I$. And if $SDI_i = 0$ that the propose scaled down the threat as much as possible, $x_F = \alpha x_I$.

For those proposers whose offer was rejected, the mean scaling down index in treatments T1 and T2 is 0.35 and 0.22, while for treatments B3 and B4, are 0.48 and 0.41, respectively. The proposer scaled down the threat more for treatment T1 and T2 than for B3 and B4 respectively [p-value =2.686e-06 and 1.234e-12]. The distribution of the scaling down index is different for treatments P and B, as Figure 4 shows it. The proportion of scaling down index between 0 and 0.04 are 48% and 53% for T1 and T2, while for B3 and B4 are 6% and 6.1%, respectively.

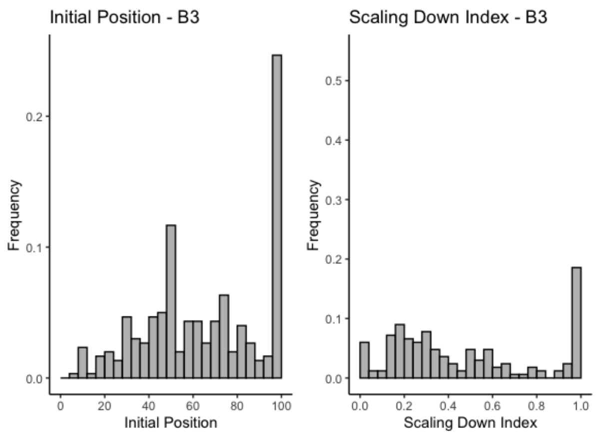
This behavior is consistent with an election of the initial threat to tie hands regarding the final threat. For treatments T1 and T2, the proposer chooses, on average, a lower initial threat than B3 and B4 and scales it down much more. It implies that the mean final threat is higher for T1 and T2 (38.3 and 41) compared with B3 and B4 (33.9 and 32.4).



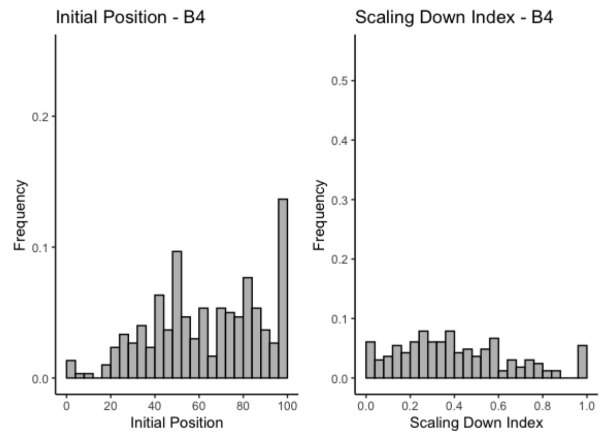
(a) Treatment T1



(b) Treatment T2



(c) Treatment B3



(d) Treatment B4

Figure 4: Initial threat and scaling down index if the offer were rejected.

Result 2: *The proposer bluffs for treatments B3 and B4.*

The theoretical prediction for the initial threat in treatments B3 and B4 is that any value higher than 25 and 30 is an equilibrium. An interesting question regarding multiple equilibria is which equilibrium to select. In that sense, the experimental result shows that the proposer chooses initial threats of 65.1 and 63.8 for B3 and B4, respectively, which are not significantly different [p-value = 0.4929]. Also, as referred above, 15% and 25% of the initial threats are above 95. It implies that the subjects chose a large initial threat (larger than for T1 and T2) as a way of bluffing about a high final threat.

Result 3: *The proposer ties her hands less than theoretically predicted.*

For treatments T1 and T2, although the proposer ties her hands by choosing an appropriate x_I. However, the intensity is lower than predicted. Theoretically, the proposer chooses a threat of 71 and then scales it down to 50 if an offer is rejected. The values obtained in the experiment are an initial treat of 44.8 and 49.2 for T1 and T2 and a final treat of 38.3 and 41.

The results suggest risk aversion to a rejected offer, as the predicted expected payoff (conditional in their x_I) is higher than the theoretically predicted. The predicted expected payoff is -1.1 and 8.1, significantly higher than -10 and 2.5 as predicted. The realized expected values—considering the final threat of the players whose offer was rejected—are also higher than theoretically predicted; -5.3 and 4.5, but lower than the predicted expected payoff conditional in theirs x_I. The result implies the responder's expected loss (predicted and realized) is lower than theoretically predicted.

On the contrary, the final threat for treatments B3 and B4 is higher than theoretically predicted, 33.9 and 32.4 versus 25 and 30. It implies the realized expected payoff for the proposer is lower than the theoretical prediction: -2.9 and 8.8 for B3 and B4, while the theoretically predicted values are 2.5 and 12.5.

4.2 Effect of the commitment on the agreement

Result 4: *The acceptance rate of the offer is low, primary because the proposer makes higher than optimal offers.*

The percentage of accepted offers is lower than 100% as theoretically predicted, and as Table 2 shows, the proportion is about 45% and not significantly different for each treatment. Table 3 suggests the high offers primarily drive the low rate of acceptance that the proposer makes across all treatments.

For each treatment, the mean offer the proposer makes is higher than the mean responder's expected loss. Less than 45% of the offers are lower or equal to the responder's expected loss. On the other hand, the acceptance rate of the responder is about 75% for each treatment for offers lower or equal to the predicted responder's loss. The acceptance rate decreases for offers higher than the predicted expected loss, but no significant difference exists among treatments.

Result 5: *There is no significant effect of the commitment to a higher final threat on choosing the offer and deciding whether to accept it.*

There is no significant difference between the mean offers made in treatment T1 and B3 (35.8 and 38.1) and between the offers in T2 and B4 (39.8 and 38.8). There is no difference in the mean accepted offer between T1 and B3 (23.8 and 26.5) and T2 and B4 (29.7 and

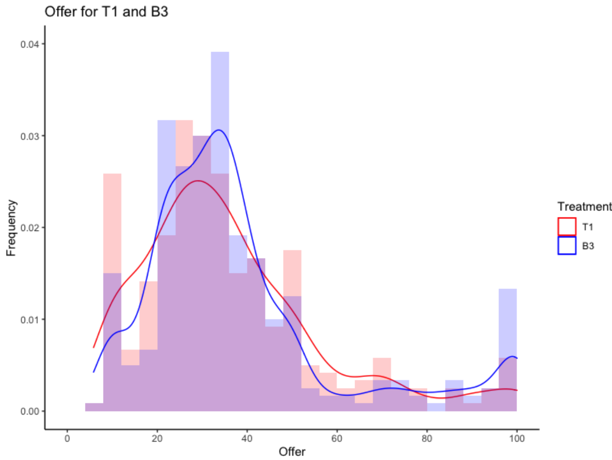
	T1 (0.7,1)	T2 (0.7,1.5)	B3 (0.2,1)	B4 (0.2,1.5)
Mean responder's expected loss	30.8	31.7	28.3	30.4
Mean offer	35.8	39.8	38.1	38.8
Mean accepted offer	23.8	29.7	26.5	26.5
Mean rejected offer	45.5	49.2	47.3	48.9
% offer (Offer $\leq$ $\mathbb{E}$Loss)	0.45	0.36	0.34	0.40
% offer (Offer $\leq 1.25 \times$ $\mathbb{E}$Loss)	0.68	0.58	0.61	0.57
% offer (Offer $\leq 1.5 \times$ $\mathbb{E}$Loss)	0.80	0.79	0.75	0.77
% accepted (Offer $\leq$ $\mathbb{E}$Loss)	0.74	0.81	0.72	0.77
% accepted (Offer $\leq 1.25 \times$ $\mathbb{E}$Loss)	0.62	0.71	0.61	0.64
% accepted (Offer $\leq 1.5 \times$ $\mathbb{E}$Loss)	0.55	0.58	0.56	0.58

Table 3: Analysis of the offers made and accepted.

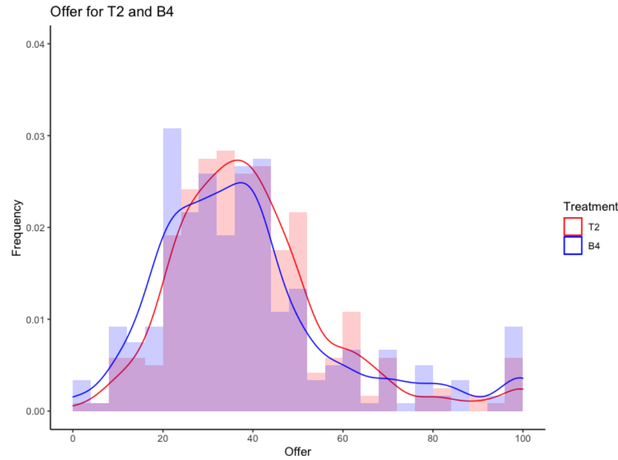
26.5). The distributions of offers are similar, as shown in Figure 5.

The theoretical prediction shows that the proposer should make higher offers for treatments T1 and T2. However, the proposer chooses a lower initial threat than predicted for T1 and T2, which implies the final threats are also lower than predicted. Furthermore, in treatments B3 and B4, if an offer is rejected, the proposer chooses a higher final threat than theoretically predicted. All this implies that the expected losses of the responder for treatments P and B are closer than theoretically predicted. Nevertheless, they are significantly different.

The estimated responder's expected losses for T1 and B3 are -30.8 and -28.3, which are significantly different. However, the realized expected payoffs are -31.5 and -30.5, which are significantly different at 5% but not at 1% (p-value = 0.038). For treatments T2 and B4, the estimated responder's expected payoffs are -31.7 and -30.4, and the realized expected payoff are -32.2 and -30.5, which are both significantly different. Therefore, the proposer making the same offer for T1 - B3 and T2 - B4 is not likely a product of the same expected payoff.



(a) Offers for Treatment T1 and B3



(b) Offers for Treatment T2 and B4

Figure 5: Distribution of offers.

Whether to accept the offer shows no difference between treatments T1 - B3 and T2 - B4. Table 4 shows the proportion of accepted offers for offers between 20 and 50, which represents about xx% of the total offers. The proportion of accepted offers per interval for T1 and B3, and T2 and B4 are not significantly different, except for offers in $[30, 40)$ for treatments T2 and B4, which the difference is significant for 5% of confidence, but not at 1% (p-value = 0.01007).

	T1 (0.7,1)	T2 (0.7,1.5)	B3 (0.2,1)	B4 (0.2,1.5)
Number of offers in [20,30)	80	71	90	77
% accepted offers in [20,30)	0.68	0.82	0.57	0.74
Number of offers in [30,40)	66	79	86	72
% accepted offers in [30,40)	0.38	0.56	0.48	0.35
Number of offers in [40,50)	47	70	41	53
% accepted offers in [40,50)	0.13	0.24	0.22	0.38

Table 4: Table

The Logit regression shows that the only relevant parameter in the acceptance decision is the offer itself and not the expected payoffs, as shown in Table 5.

	T1	T2	B3	B4
(Intercept)	5.81	4.24	8.66	−5.85
	(4.50)	(3.97)	(9.24)	(6.12)
Offer	-0.13^{***}	-0.13^{***}	-0.10^{***}	-0.12^{***}
	(0.02)	(0.02)	(0.01)	(0.02)
Initial threat	0.10	0.02	0.01^{*}	0.00
	(0.06)	(0.05)	(0.01)	(0.01)
Round	0.03	0.08	0.01	−0.03
	(0.05)	(0.05)	(0.05)	(0.05)
Order	−0.39	−0.55	−0.35	−0.96
	(0.83)	(0.82)	(0.78)	(0.82)
Responder's expected payoff	0.21	0.05	0.26	−0.60
	(0.22)	(0.20)	(0.39)	(0.33)
Proposer's expected payoff	0.25^{*}	0.06	0.49	−0.55
	(0.10)	(0.07)	(0.83)	(0.38)
Num. obs.	300	300	300	300

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 5: Logit regressions.

5 Conclusion

In general, for treatments T1 and T2, the subjects acting as proposers choose to tie their hands by choosing a large initial threat. In comparison, in treatments B3 and B4, the subjects bluff by also choosing a larger threat (larger than treatments T1 and T2) but not tying their hands.

The initial values for T1 and T2 are significantly lower than the values theoretically predicted, which might be explained by the risk aversion of not being able to scale down the final threat if the offer is rejected. The data shows that the mean final threat is higher for treatments T1 and T2 than for B3 and B4.

An interesting result is that the proposer's mean offer is significantly higher than the responder's expected payoff (optimally calculated conditional on the initial threat). The responder accepts more than 70% of the offers that are optimal (lower or equal to their expected loss) and more than half of the offers that are 1.5 times the expected payoff. The proportion of accepted offers is low (about 40%) because the proposer's offers are high.

For the cases in which the offer was rejected, the final threat is higher than the optimal final threat, although the distribution is centered around the optimal final threat.

The realized expected payoffs are significantly higher for the proposer than the theoretically predicted for treatments T1 and T2 and lower for treatments B3 and B4. However, as predicted, the expected payoff is higher for B3 and B4 compared to T1 and T2, respectively.

The theoretical predictions imply that for treatments T1 and T2, the initial threat, offer, and final threat are the same, as the high commitment dominates the effect of ϕ. However, the data shows that the initial, offer and final threats are higher for T2 than for T1. It is consistent with proposers not fully using the commitment power to tie their hands and only doing it partially, which implies the value ϕ plays an important role.

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Appendices

A Instructions

Introduction

Welcome to this experiment. The decisions you make during this experiment will determine how much money you earn. You will be paid in cash, privately, at the end of our experiment.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

For today's experiment, you will receive an initial payment of $18, in addition to the $7 show-up fee. Your earnings in the experiment are expressed in Experimental Francs (EF). 5 EF are worth $1. At the end of the experiment, your total earnings will be paid to you in cash, privately.

The experiment consists of two parts, labeled Part 1 and Part 2. Each part has 15 decision rounds. We will read you the instructions for Part 1 now. After completing Part 1 we will read instructions for Part 2. After we have read the instructions, there will be time to ask clarifying questions. When we are done going through the instructions for Part 1, each of you will have to answer a few brief questions to ensure everyone understands.

Groups and roles

At the beginning of each round, all participants will be randomly divided into groups of two. You will only interact with the other participant randomly assigned to your group through the computer interface. You will not know who the other member of your group is. Within each round you will have no interaction with participants who are randomly assigned to other groups.

Groups are randomly determined every round, so that the other participant in your group is probably not the same between rounds.

In each round, one participant in each group will be the PROPOSER, and the other participant will be the RESPONDER. These roles are randomly determined in each group in each round, so that you will probably not be in the same role in all rounds.

Round overview

During each round, an outcome is determined. There are two possible outcomes: OUTCOME P and OUTCOME R.

Each round is comprised of several stages.

Stage 1: The PROPOSER chooses an INITIAL POSITION, which is a number between 0 and 100, inclusive.

Stage 2: The PROPOSER chooses an OFFER, which is also a number between 0 and 100, inclusive.

Stage 3: The RESPONDER sees the INITIAL POSITION and the OFFER. After doing so, the RESPONDER decides whether to accept or reject the OFFER. If the RESPONDER rejects the OFFER, then the round earnings of the RESPONDER and the PROPOSER are both reduced by 10. If the RESPONDER accepts the OFFER, the round ends, and the outcome is OUTCOME P.

The round earnings are:

PROPOSER: OFFER

RESPONDER: $(-1)\cdot$ (OFFER)

Stage 4: If the RESPONDER rejects the OFFER, the PROPOSER chooses a FINAL POSITION. The FINAL POSITION is any number between 0.2· (INITIAL POSITION) and the INITIAL POSITION, inclusive. That is, when choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 80%. The FINAL POSITION cannot be higher than the INITIAL POSITION.

Stage 5: If the RESPONDER rejects the OFFER, the outcome is determined using the FINAL POSITION chosen by the PROPOSER. The outcome will be OUTCOME R with probability (FINAL POSITION)%, and will be OUTCOME P with probability (100 – FINAL POSITION)%. Note that the higher the FINAL POSITION, the lower the probability that the outcome is OUTCOME P.

If the outcome is OUTCOME R, round earnings are

PROPOSER: $(-1) \cdot$ (FINAL POSITION) – 10

RESPONDER: $0 - 10 = -10$

If the outcome is OUTCOME P, round earnings are

PROPOSER: $(1.5) \cdot$ (FINAL POSITION) – 10

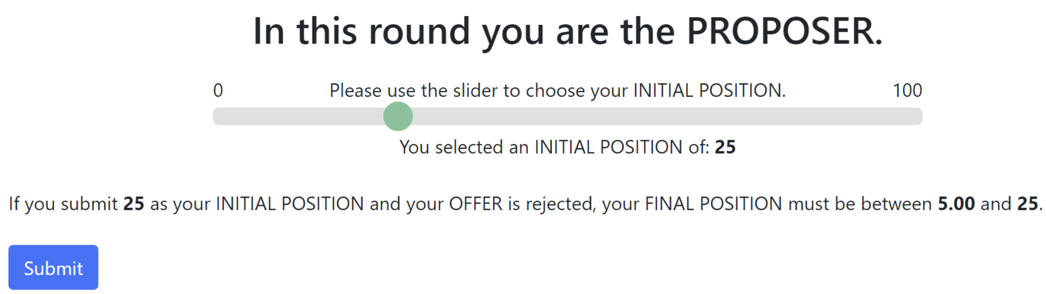
RESPONDER: $(-1) \cdot$ (FINAL POSITION) – 10

PROPOSER chooses their INITIAL POSITION

At the beginning of each round the PROPOSER chooses an INITIAL POSITION, which can be any number between 0 and 100, inclusive. The INITIAL POSITION is chosen by moving the slider to the desired number and clicking "Submit".

When the PROPOSER moves the slider, the text below the slider will indicate the FINAL POSITIONs that could be chosen if the current position of the slider were submitted as the INITIAL POSITION. Recall that when choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 80%, and the FINAL POSITION cannot be higher than the INITIAL POSITION.

Note that the starting location of the slider is chosen randomly.



PROPOSER chooses their OFFER

After submitting the INITIAL POSITION, the PROPOSER chooses an OFFER. The OFFER can be any number between 0 and 100, inclusive. The OFFER is chosen by moving the slider to the desired number and clicking “Submit”.

When choosing the OFFER, the PROPOSER’s screen will display:

1. Their INITIAL POSITION
2. The FINAL POSITIONs that they can choose if their OFFER is rejected.
3. A reminder that if the OFFER is rejected by the RESPONDER, the round earnings of the PROPOSER and the RESPONDER will decrease by 10.
4. A second slider whose end points correspond to the possible FINAL POSITIONs the PROPOSER can choose if the OFFER is rejected. The PROPOSER can use this slider to explore scenarios corresponding to possible FINAL POSITIONS. For any possible FINAL POSITION, a bar chart will illustrate the probability that the outcome will be OUTCOME R or OUTCOME P, and will state the round earnings that both the PROPOSER and RESPONDER would receive.

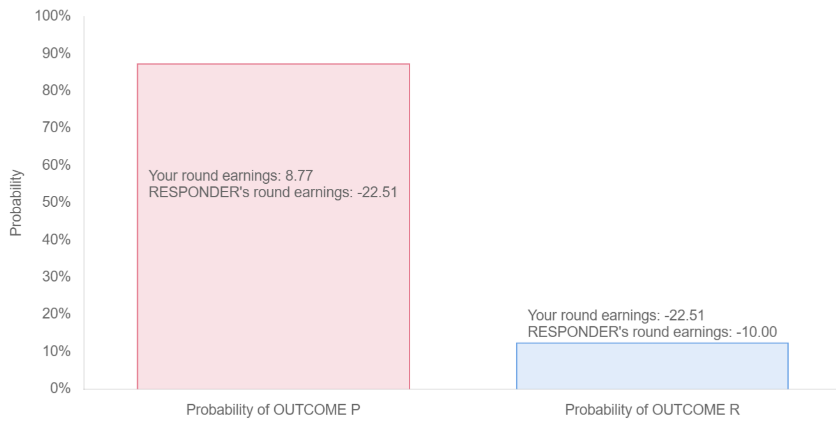
Note that the starting location of the slider is set to the previously chosen INITIAL POSITION.

Your INITIAL POSITION is 25.0

If your OFFER is rejected, your FINAL POSITION must be between **5.0** and **25.0**.
If the RESPONDER rejects your OFFER your round earnings and the round earnings of the RESPONDER will be reduced **10**

0 Please use the slider to choose your OFFER. 100

You can use the slider below to explore possible outcomes if the RESPONDER rejects your offer.



FINAL POSITIONS you can choose if your OFFER is rejected.

5.0 Potential FINAL POSITION: **12.51** **25.0**

RESPONDER accepts or rejects the OFFER

After the PROPOSER chooses the INITIAL POSITION and the OFFER, the RESPONDER sees them, and decides whether to accept or reject the OFFER.

The RESPONDER accepts the OFFER by clicking "Accept" and rejects the OFFER by clicking "Reject".

Next to the "Accept" button, the RESPONDER's screen will state that if they accept the OFFER the outcome will be OUTCOME P, their round earnings will be equal to $(-1) \cdot$ OFFER, and the PROPOSER's round earnings will be equal to the OFFER.

Next to the "Reject" button, the RESPONDER's screen will state that if they reject the OFFER, both their round earnings and the round earnings of the PROPOSER will decrease by 10. The screen will also indicate the FINAL POSITIONS that the PROPOSER can choose if the OFFER is rejected. (Recall that when choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 80%, and the FINAL POSITION cannot be higher than the INITIAL POSITION.).

In addition, the RESPONDER's screen will display a slider whose end points correspond to the possible FINAL POSITIONs the PROPOSER can choose if the OFFER is rejected. The RESPONDER can use this slider to explore scenarios corresponding to possible FINAL POSITIONS. For any possible FINAL POSITION, a bar chart will illustrate the probability that the outcome will be OUTCOME R or OUTCOME P, and will state the round earnings that both the PROPOSER and RESPONDER would receive.

In this round you are the RESPONDER

The PROPOSER chose an INITIAL POSITION of **25.0**
The PROPOSER chose an OFFER of **23.84**

If you accept

The round ends.
The outcome would be OUTCOME P.
Your round earnings would be: **-23.84**
PROPOSER round earnings would be: **23.84**

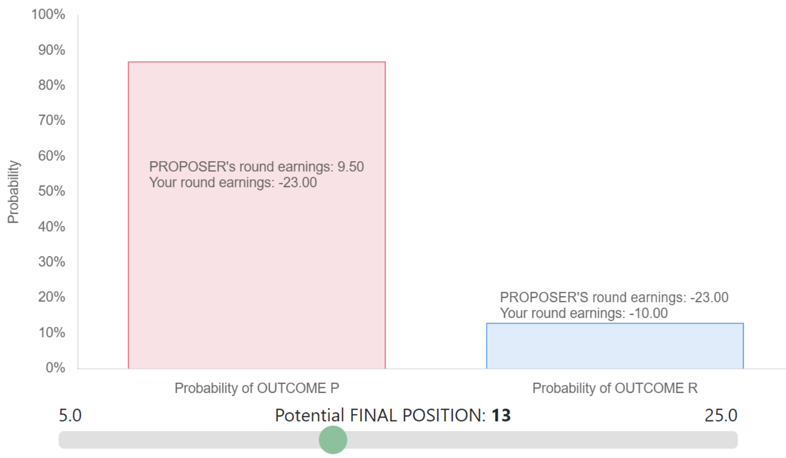
Accept

If you reject

Your round earnings and the round earnings of the PROPOSER will decrease by **10**
The PROPOSER will chose a FINAL POSITION between **5.0** and **25.0**

Reject

You may use the slider below to explore possible outcomes which will be determined by the PROPOSER's choice of FINAL POSITION.



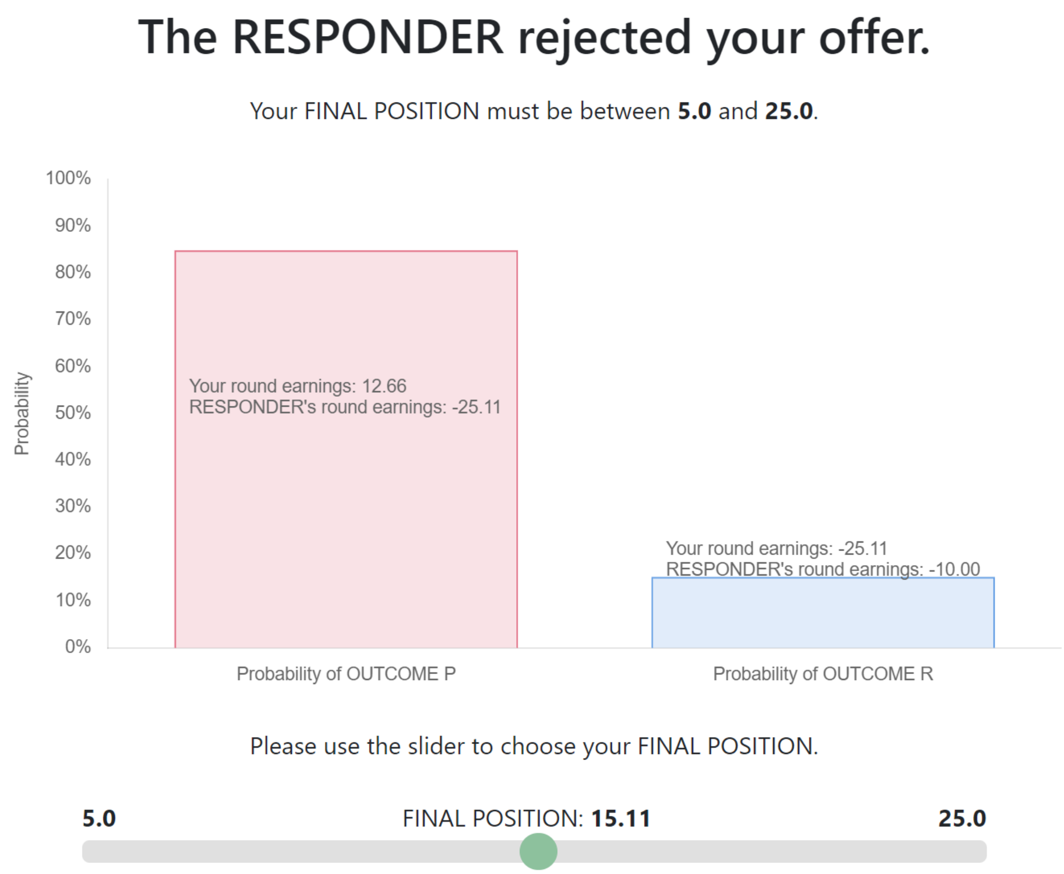
PROPOSER chooses their FINAL POSITION

If the RESPONDER rejects the OFFER the round earnings of the RESPONDER and the PROPOSER decrease by 10. The PROPOSER then chooses a FINAL POSITION. When choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 80%. The FINAL POSITION cannot be higher than the INITIAL POSITION.

The FINAL POSITION is chosen by moving the slider to the desired number and clicking "Submit".

When the PROPOSER moves the slider, a bar chart above the slider will indicate the probability that the outcome will be OUTCOME P and the probability that the outcome will be OUTCOME R if the current position of the slider were submitted as their FINAL POSITION. This bar chart will also state the the round earnings that both the PROPOSER and RESPONDER would receive in each possible outcome if the current position of the slider were submitted as the FINAL POSITION.

Note that the starting location of the slider is chosen randomly.



Outcome when the OFFER is rejected

If the RESPONDER rejects the OFFER, the outcome is determined using the FINAL POSITION chosen by the PROPOSER. The outcome will be OUTCOME R with probability (FINAL POSITION)%, and will be OUTCOME P with probability (100−FINAL POSITION)%.

If the outcome is OUTCOME R, round earnings are

PROPOSER: $(-1) \cdot$ (FINAL POSITION) $- 10$

RESPONDER: $0 - 10 = -10$

If the outcome is OUTCOME P, round earnings are

PROPOSER: $(1.5) \cdot$ (FINAL POSITION) $- 10$

RESPONDER: $(-1) \cdot$ (FINAL POSITION) $- 10$

Example 1

The PROPOSER chooses an INITIAL POSITION of 45, and an OFFER of 30.

The RESPONDER rejects the OFFER, so the round earnings of both the RESPONDER and the PROPOSER are decreased by 10. The PROPOSER chooses a FINAL POSITION. This FINAL POSITION must be between $0.2 \cdot 45$ and 45. That is, the FINAL POSITION must be between 9 and 45.

The PROPOSER chooses a FINAL POSITION of 40. This means that there is a 40% probability that the outcome will be OUTCOME R, and a 60% probability the outcome will be OUTCOME P.

When the outcome is resolved, it is OUTCOME R. Round earnings are

PROPOSER: $-40 - 10 = -50$

RESPONDER: $0 - 10 = -10$

Example 2

The PROPOSER chooses an INITIAL POSITION of 40, and an OFFER of 25.

The RESPONDER accepts the OFFER, so the round ends and the outcome is OUTCOME P. Round earnings are:

PROPOSER: 25

RESPONDER: −25

Example 3

The PROPOSER chooses an INITIAL POSITION of 60, and an OFFER of 35.

The RESPONDER rejects the OFFER, so the round earnings of both the RESPONDER and the PROPOSER are decreased by 10. The PROPOSER chooses a FINAL POSITION. This FINAL POSITION must be between $0.2 \cdot 60$ and 60. That is, the FINAL POSITION must be between 12 and 60.

The PROPOSER chooses a FINAL POSITION of 50. This means that there is a 50% probability that the outcome will be OUTCOME R, and a 50% probability the outcome will be OUTCOME P. When the outcome is resolved, it is OUTCOME P. Round earnings are

PROPOSER: $(1.5) \cdot (50) - 10 = 65$

RESPONDER: $-50 - 10 = -60$)

Results of a round

At the end of each round the results of the round will be displayed on the screen. The results you will see are:

1. Your role in the round.
2. The INITIAL POSITION chosen by the PROPOSER.
3. The OFFER chosen by the PROPOSER.
4. Whether the OFFER was accepted or rejected by the RESPONDER.
5. If relevant, the FINAL POSITION chosen by the PROPOSER.
6. The outcome of the round.
7. The round earnings of the PROPOSER.
8. The round earnings of the RESPONDER.

Selecting round for payment

Once all 30 rounds of the experiment have been completed, 1 round will be randomly chosen for payment. Each of the 30 rounds are equally likely to be chosen for payment.

Your payment for today's session will be the sum of your earnings in the round randomly chosen for payment, the initial payment of $18 and the $7 show-up fee.

Summary

- During each round, there are two possible outcomes: OUTCOME R and OUTCOME P.
- First, the PROPOSER chooses an INITIAL POSITION, which is a number between 0 and 100, inclusive.
- The PROPOSER then chooses an OFFER, which is also a number between 0 and 100, inclusive.
- The RESPONDER then sees the INITIAL POSITION and the OFFER and decides whether to accept or reject the OFFER. If the RESPONDER rejects the OFFER then the round earnings of both the RESPONDER and the PROPOSER decrease by 10. If the RESPONDER accepts the OFFER, the outcome is OUTCOME P.

  Round earnings are:

  PROPOSER: OFFER

  RESPONDER: $(-1)\cdot$ (OFFER)
- If the RESPONDER rejects the OFFER, the PROPOSER chooses a FINAL POSITION. This FINAL POSITION is any number between $0.2\cdot$ INITIAL POSITION and the INITIAL POSITION. That is, when choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 80%. The FINAL POSITION cannot be higher than the INITIAL POSITION.
- If the RESPONDER rejects the OFFER, the outcome of the round is determined using the FINAL POSITION chosen by the PROPOSER. The outcome will be OUTCOME R with probability (FINAL POSITION)%, and will be OUTCOME P with probability (100 – FINAL POSITION)%.

  If the outcome is OUTCOME R, round earnings are

  PROPOSER: $(-1)\cdot$ (FINAL POSITION) $-$ 10

  RESPONDER: $0 - 10 = -10$

  If the outcome is OUTCOME P, round earnings are

  PROPOSER: $(1.5)\cdot$ (FINAL POSITION) $-$ 10

  RESPONDER: $(-1)\cdot$ (FINAL POSITION) $-$ 10

Instructions for Part 2

Part 2 of the experiment is the same as Part 1, except that if the RESPONDER rejects the OFFER, the PROPOSER must choose a FINAL POSITION that is between 0.7·INITIAL POSITION and their INITIAL POSITION. That is, when choosing the FINAL POSITION, the PROPOSER can reduce their INITIAL POSITION by no more than 30%. The FINAL POSITION cannot be higher than the INITIAL POSITION.

For example, suppose the PROPOSER chooses an INITIAL POSITION of 30. Then the FINAL POSITION must be between 21 and 30.