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Keywords
experiment, ultimatum game, fairness, uncertainty, framing, contingent weighting

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"Information in Ultimatum Games: An Experimental Study"

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Information in Ultimatum Games: An Experimental Study*

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Abstract

This study reports on a series of variations of the ultimatum game. The experiment controls the amount and type of information known to the responder in the game. In two treatments, she knows both the absolute (money) and relative (fairness) payoffs from an offer. In the other two, she knows either only the absolute or only the relative payoffs. The predictions of seven models for these treatments are tested: subgame-perfect, Bolton's equilibrium, Ochs and Roth's absolute threshold, Ochs and Roth's percentage threshold and a descriptive hypothesis.

JEL Classification Codes: C9 Laboratory Experiments
C72 Noncoperative Games

Keywords: Experiment, Ultimatum Game, Fairness, Uncertainty, Framing, Contingent Weighting

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Information in Ultimatum Games: An Experimental Study

I. Introduction

Ultimatum bargaining is a building block for more complicated, and more descriptive, types of bargaining.[1] Given its importance in models of strategic behavior, it has been studied extensively through experimental methods. This research has found that proposers make larger offers than game-theoretic analysis would predict. Responders also reject small but positive offers, again contrary to the predictions of game theory.[2] The most popular explanation for these outcomes is that subjects care about fairness: in addition to valuing their absolute payoffs (money earned from the game), subjects care about their payoffs relative to those of their bargaining partner (fairness of the division).[3]

There have been a number of suggestions as to how preferences about fairness are exhibited in bargaining games. This study was designed to differentiate between and to test these models of fairness preferences.[4] The results of this study are consistent with the notion that subjects care about both money and fairness. However the framing of the game being played affects its outcome—offers made in percentage terms rather than in dollar amounts induce higher demands, and thus "fairer" outcomes. An explanation for this effect from the *contingent weighting* literature is offered which suggests placing more "weight" or value on the fairness part of one's preferences when offers are made in percentage terms and relative payoffs are particularly salient.

The experiment consists of four treatments in which subjects divide a $10 pie in an ultimatum game. The treatments are depicted in Table 1 below and are designated by a two-character code. The first character represents the form in which offers are made (dollar amounts [$] or percentages [%]) and the second represents the state of the responder's knowledge (Informed about the size of the pie [I] or Uninformed [U]).

Insert Table 1 here

First is the classical ultimatum game ($I) in which the size of the pie to be divided is common knowledge and offers are made in dollars. In the $U treatment, only the proposer knows the size of the pie; the responder is given no information about its size, although she knows the dollar offer she faces. In the %U treatment, the responder is offered only a percentage of the pie—not the corresponding dollar amount—and again, she does not know the total pie's size. The final treatment (%I) completes the 2x2 design; with both players informed about the size of the pie, the offer is made in percentage terms. The information conditions between treatments one and four are identical; only the form of the offer (the frame of the problem) differs.

The subgame-perfect equilibrium (offer ε, accept) is the same in all four experimental treatments. However, two empirical differences emerge across the treatments. First, in the treatments in which offers are made in dollars, uninformed responders face and accept substantially lower offers than their informed counterparts: the average offer in treatment $U is significantly lower than the average offer in $I. Second, treatments $I and %I in which the situations are identical except for the description of the offer, evoke different responder behavior: average demands made by responders in treatment %I are significantly higher than those made in any other treatment, including treatment $I. This result is consistent with individuals placing greater value on fairness when relative payoffs are particularly salient.

Section II describes the experimental procedure and design. Section III outlines the theoretical predictions of the experiments and section IV describes the results. Section V presents some analysis and section VI contains an informal discussion of one possible explanation for the observations. Section VII describes other related experiments and their outcomes and section VIII concludes.

II. Experimental Procedure and Design[5]

Subjects were recruited from a variety of large undergraduate lecture classes at Harvard University Summer Session, 1992 and Fall, 1992 courses. Each treatment of the experiment was run in two sessions by the same experimenter. The sessions for each treatment were scheduled within one day of each other. Evidence that economics students play ultimatum games differently from all other students is mixed (Carter and Irons (1991), Kagel, Kim and Moser (1992)); to sidestep such a debate, no economics classes were used for recruiting. Subjects were told that they could stay after class, complete a questionnaire and participate in a decision problem (both of which together would take 30 to 45 minutes) to earn a guaranteed $5, possibly more.[6] Subjects who remained were seated along the outside aisles of the classroom and asked to complete a decision-making questionnaire (unrelated to the ultimatum game) for which they would be paid $5 at the end of the session. Ultimatum game instructions were then distributed according to their chosen seating. Subjects at opposite ends of the same aisle were not paired with one another, nor were subjects seated closely together. A composite version of the instructions was read aloud, with any questions answered publicly.[7] A short quiz about the decisions to be made, and the payoffs which resulted from those decisions, was given and subjects' answers checked—and mistakes corrected—privately. All treatments involved subjects splitting a $10 pie, although not all subjects knew the size of the pie in all treatments.[8] At this point proposers, whose instructions included an offer/acceptance sheet, made their offers in writing. These sheets were collected and distributed to the appropriate responders. Responders replied to their respective offers; these responses were shown to (but not left with) the appropriate proposer. All subjects then completed a short questionnaire about their perceptions of the game, brought their materials to the experimenters, were paid individually $5 plus their earnings, and left. All subjects participated in one and only one ultimatum decision, eliminating opportunities either for reputation effects or for learning by subjects.

This experiment manipulates both the amount and type of information the responder has. Offers are made either in dollar or percentage amounts. The responder can know the size of the pie to be divided or not. In treatments $I and %I the responder has complete information; she knows both the absolute amount of money and the percentage of the pie she is being offered. These two treatments leave the responder with logically equivalent decisions. In treatment $U she knows only the absolute amount of money she is being offered and not the relative payoffs (fairness) of the proposal. In treatment %U she knows only the percentage of the pie she is being offered and not the absolute (money) payoffs.

This paper will focus on the predictions of a number of theories for comparisons between treatments of this experiment. Two considerations I wish to address here are preferences for fair outcomes on the part of the proposers and unknown priors about the pie size on the part of the responders. There is some evidence that a proportion of the population of proposers has a preference for fairness, and is willing to give up money in order to produce equal monetary outcomes (see Forsythe *et al.*'s (1994) and Hoffman *et al.*'s (1992) dictator game data). If this is so, a random assignment of subjects to treatments should equalize the proportion of these "fair" types in the role of proposer in each of the four treatments. By focusing on *comparisons* between the various treatments, offers from these types of subjects should wash out. If anything, this washing out should serve to make the data from the various treatments more alike, which is what the subgame-perfect hypothesis predicts. Ironically then, having proposers with preferences for fairness will tend to *support* the subgame-perfect hypothesis.[9]

A similar random-assignment argument holds for the distribution of prior beliefs about the size of the pie (when it is unknown) held by responders. If the sample is truly random, these priors should be distributed identically in the two uninformed treatments, influencing outcomes in both treatments similarly. So by comparing differences between these two treatments, the differences in subjects' priors are not being measured.[10]

III. Theoretical Predictions

I examine five theories and their predictions about outcomes in this experiment. Each of these theories is composed of two parts. The first specifies the arguments of the responder's utility function. The second stipulates that proposers know these arguments, and act accordingly—that is, that they play best responses to the responder's demands.[11]

The subgame-perfect equilibrium (with pure self-interest) predicts no differences among these four treatments; responders should accept any positive amount or percentage.[12] Thus offers and responses should be identical in all four treatments $I, $U, %U and %I.

Bolton's (1991) comparative equilibrium relaxes the assumption that the responder will accept all positive offers. Bolton describes a utility function containing arguments of both absolute payoffs (money) and relative payoffs (an index of fairness). Players behave as expected-utility maximizers; in an ultimatum game, the responder would accept an offer of $z \leq \pi/2$ only if the utility from accepting the offer z were greater than or equal to the utility of rejecting the offer.[13] Since proposers know this, they offer enough to make responders indifferent between accepting and rejecting the offer, which critical amount, depending on the preferences in question, may very well be significantly more than ε. This theory predicts that offers and demands in treatments in which the pie size is known, $I and %I, will be identical, as the form of the offer has no effect on its acceptance.[14]

Ochs and Roth's (1989) minimum-absolute threshold hypothesis suggests that the minimum a given responder will accept is a constant dollar amount but need not be particularly small. It thus predicts that the acceptance patterns from treatments where the responder can calculate her absolute (money) payoff should be the same—all the responder cares about is getting her absolute minimum threshold; the size of the pie doesn't enter the analysis at all. Thus offers in three treatments $I, $U and %I should be identical. In treatment %U, the responder's belief about the pie size would determine whether or not she expects to receive this absolute minimum threshold from a given percentage offer, eliminating the possibility of testable predictions without further assumptions about those beliefs.

Ochs and Roth's (1989) minimum-percentage threshold hypothesis suggests that the minimum a given responder will accept is a fixed percentage of the pie. Thus the acceptance patterns from treatments where the responder can calculate her relative payoff should be the same—if the responder receives her minimum percentage she will accept, regardless of her beliefs about the absolute amount of money she will receive. Thus offers in three treatments $I, %U and %I should be identical. In treatment $U she cannot discern the percentage of the pie she is being offered with certainty, she again has to rely on her beliefs about the size of the pie; the theory makes no testable predictions without additional assumptions.[15]

A final, descriptive hypothesis relies on the observation that in Nash bargaining games subjects move toward equal divisions in situations where they know their counterpart's payoff as well as their own (Roth and Malouf (1979, 1982), Roth and Murnighan (1982)). A weak version of this hypothesis suggests that in treatment $U, where responders know only their own absolute (money) payoff, offers will be lower and acceptance rates higher than in treatment $I, where responders know both their own absolute (money) payoff and that of their proposer (and thus the relative (fairness) payoff). Since prior experiments have only examined the dollar-bargaining cases and not the percentage-bargaining cases, this hypothesis makes no predictions in the percentage-offer treatments.

A summary of the predictions from various theories follows:

Subgame-perfect equilibrium: Acceptance and offering patterns should be identical in all four treatments.[16] **$I=$U=%U=%I**

Bolton's comparative equilibrium: Acceptance and offering patterns should be identical in treatments $I and %I. **$I=%I**

Ochs and Roth's minimum-absolute threshold of acceptance: Acceptance and offering patterns should be identical in treatments $I, $U and %I. **$I=$U=%I**

Ochs and Roth's minimum-percentage threshold of acceptance: Acceptance and offering patterns should be identical in treatments $I, %I and %U. **$I=%U=%I**

Descriptive weak version: Acceptance and offering patterns should be higher in treatment $I than in treatment $U. **$I>$U**

IV. Results

The offers and responses from these four treatments are shown in Figures 1-4 below. Each figure depicts accepted and rejected offers, as well as the mean offer.

Insert Figures 1-4 here

Means, standard deviations and sample sizes of offers for each treatment are summarized in Table 2, below.

Insert Table 2 here

The average offer in the classical ultimatum game treatment ($4.50) is 93¢ greater than the average offer in the uninformed version of this game ($3.57). The difference between average offers in the percentage-informed and -uninformed treatments is positive but not as large (28¢). Comparing average offers between dollar-offer treatments and percentage-offer treatments suggests no regularities (+30¢ in the informed case, -35¢ in the uninformed case).

Offers in treatment $I are similar to those of other $10 pie ultimatum game experiments. The mean offer in $I was $4.50. In Carter and Irons (1991) the mean offer for the noneconomist group was $4.56. Prasnikar and Roth (1992) report a mean offer over ten rounds of $4.16 and Forsythe *et al.*(1994) have a mean offer of $4.67.

The classical ultimatum game's rejection rate is also comparable to those of other one-shot ultimatum games. Seven percent of offers were rejected in this condition compared with a rejection rate of 8.3% in a similar treatment of Hoffman *et al.* (1992)[17] and a rejection rate of 4.17% in Forsythe *et al.* (1994).

V. Analysis

A. *Offers*

The Wilcoxon rank sum test compares each set of observations with each other and reports the probability that the underlying distributions are the same.[18] Table 3 below reports the p-values for comparisons between each treatment.

Insert Table 3 here

The main result from this analysis is that the offers in the classical ultimatum game ($I) are statistically significantly greater than those in the game in which offers are made in dollars and the responder is uninformed about the size of the pie ($U) (p<.01). Weaker statistical support is found for other comparisons.[19]

That *any* of these offer distributions differ is not consistent with the subgame-perfect hypothesis, which predicted that offers in each treatment would be identical. The absolute-threshold hypothesis also predicted that offers in treatments $I and $U would be identical, which was not the case.

B. Responses

The percentages of rejections are listed in Table 4 below.

Insert Table 4 here

One interesting result is the high frequency of rejections in the %I treatment, even though offers in that treatment are not significantly different than offers any of the other three treatments. Statistically comparing the proportion of rejections in each treatment suggests more rejections in treatment %I than in all other treatments, at the 5% level for %U and $U just missing it for $I (p=.0154 for %U, p=.0239 $U and p=.0618 $I).[20] Further evidence of high demands leading to high rejection rates in treatment %I is presented in the next subsection.

C. Questionnaire Responses

1. <u>Raw Responses</u>

In addition to providing the data above, subjects were asked about their strategy and beliefs in a post-experimental questionnaire.[21]

In all treatments, responders were asked the provide the lowest offer they would have accepted (in percentage treatments, the lowest percentage offer and in dollar treatments the lowest dollar offer). Answers such as "I would have accepted anything" were coded as the subgame-perfect prediction of 1¢ or .1%. In treatments with an unknown pie size, responders were also asked their beliefs about the size of the pie. Means and standard deviations for the answers to these questions are presented in Table 5.

Insert Table 5 here

Figures 5-8 show the reported demands for the four treatments.

Insert Figures 5-8 here

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2. Analysis of Responses

An analysis similar to that used on offers can test whether responders' demands in different treatments could have been generated from the same distributions. Caution should be used in interpreting these results, as these data are only reported, not actual, demands. Nonetheless, Table 6 presents the comparisons.

Reported demands in treatment %I are significantly higher than those in all other treatments ($p<.01$). This result was not predicted by any of the discussed theories, but is consistent with the high levels of rejections actually observed in treatment %I.

Insert Table 6 here

The difference in demands is inconsistent with Ochs and Roth's minimum-percentage threshold hypothesis which predicted demands in %I would be the same as those in %U and $I. The difference in demands between %I and $I suggests a framing effect. Subjects seem to care more about fairness when it is salient—the weight they put on the fairness aspect of their preferences increases when offers are made in percentage terms.

VI. A Summary of Results, Their Implications and Some Explanations

There are three main results emerging from this study.

(1) Offers in $I are significantly greater than offers in $U (p<.01). This result is consistent with the descriptive hypothesis, Bolton's equilibrium and Ochs and Roth's minimum-percentage threshold hypotheses but inconsistent with the subgame-perfect equilibrium solution or with Ochs and Roth's minimum-absolute threshold hypothesis.

(2) Demands in %I are significantly greater than those in any other treatment (p<.01) and in particular are greater than those in treatment %U. This is not consistent with Ochs and Roth's minimum-percentage threshold hypothesis.

(3) Demands in %I are significantly greater than those in any other treatment (p<.01), and in particular, are greater than demands in treatment $I. This is not consistent with predictions of any of the theories presented.

One of the more intriguing explanations of result (3) involves applying models of contingent weighting to this strategic situation (Tversky, Sattath and Slovic (1988)). In such an application, the marginal tradeoffs between money and fairness would depend on the treatment in which the responder plays. In this setting, fairness becomes more salient in percentage treatments, leading one to expect that the marginal utility for fairness at each money level would be higher in percentage treatments than in absolute treatments. This prediction is certainly borne out in treatments $I and %I, where demands are higher (more fair) in the latter treatment than in the former. However, this model must be modified to accommodate the lack of such an effect in the uncertain treatments ($U and %U) where demands are indistinguishable (p=.4564).

VII. Other Ultimatum Experiments and Their Outcomes

Perhaps the most consistent finding of past ultimatum experiments is that subjects do not play the subgame-perfect equilibrium strategy. The robust result is that proposers offer significantly more than ε to responders and that responders sometimes reject positive offers. The outcomes of many ultimatum game experiments and their variations are summarized in Thaler (1988), Güth and Tietz (1990) and Roth (forthcoming).[22]

This study uses incomplete and imperfect information in an attempt to illuminate the factors involved in this behavior and to separate various theories explaining it. A similar approach has been used in studies of Nash bargaining. Roth and Malouf (1979) examined and accepted the hypothesis that "when the players know both their opponents' monetary payoffs as well as their [opponents'] utilities, the outcome of (Nash) bargaining will be influenced by interpersonal comparisons, in the direction of equal gains" (p. 585). Forsythe, Kennan and Sopher (1991) also examined Nash bargaining with varying information. They focused on the incidence of strikes (no agreement—similar to rejections here) in information conditions when the uninformed player knew the distribution from which the pie is drawn, but not the size of the pie itself. As in Roth and Malouf (and unlike in Forsythe *et al.*), in this study subjects are *not* given prior probability distributions about the size of the pie (the hidden information).

Four recent experiments have examined ultimatum games with varying information conditions, two of which control the responders' priors and two of which involve unknown priors on the part of responders.

Mitzkewitz and Nagel (1993) compared "offer" and "demand" versions of the ultimatum game. In both games, the proposer was informed about the size of the pie and the responder knew only its probability distribution. The offer game is similar to the one used in this study (but run with controlled priors over the pie), however no comparison between it and an ultimatum game with perfect information about the pie size was presented.

Rapoport, Sundali and Potter (1992) controlled and manipulated the variability of the prior distribution of the pie size given to the responder. They always informed the proposer about the actual size of the pie and gave the responder a distribution from which the pie size was drawn. The mean of this distribution was constant, although its range varied between treatments. As the range of this prior increased, proposers decreased their offers and responders accepted these smaller offers more often.

Straub and Murnighan (forthcoming) ran a comprehensive survey/experiment asking subjects to respond to ranges of ultimatum offers when the pie size was known and when it was unknown (with no priors provided to the subjects, as in this study), and to make ultimatum offers when the pie size was known and unknown to their responders. They found a much greater willingness to accept very low offers (1¢) when the size of the pie was unknown than when it was known. Subjects adjusted their offers accordingly, offering significantly less when the size of the pie was private information than when it was public. However the offers subjects faced were pre-selected by the authors rather than endogeneously generated in the experiment.

Finally, Kagel, Kim and Moser (1992) extended Roth and Malouf's Nash bargaining method to the ultimatum game. The proposer offered a division of 100 chips valued differently by each player and the responder accepted or rejected the offer. Three information conditions were run. In the first, both players knew their own and each other's value per chip. In the second (third) treatment, both players knew their own chip value, but only the proposer (responder) knew the other player's chip value. The results from this experiment supported the descriptive hypothesis; when relative (fairness) payoffs were known by the players (condition one), divisions tended to be more equal than when information was one-sided and only absolute (money) payoffs were known by the players (conditions two and three).

These studies reinforce the result that when the size of the pie is not known by the responder (whether or not she is given prior beliefs about it), offers and demands fall. This paper is the first to examine percentage offers and demands in this context. With these treatments, alternative explanations for these results (involving absolute and relative payoffs) can be separated and tested independently.

VIII. Conclusions

Ultimatum bargaining is used as a building block for more complex (and realistic) kinds of bargaining. Past experimentation has demonstrated that preferences for fairness play a role in laboratory versions of these games. The experiment reported in this paper was designed to determine the importance of this preference for fairness under various informational and salience conditions. Particularly, what role does information about absolute (money) and relative (fairness) payoffs play in determining offers and responses? And when relative (fairness) payoffs are made more salient, by having offers made in percentages, are preferences for fairness more influential than when offers are made in dollars? The experimental design also separated and to tested the predictions of five different hypotheses about fair preferences. Three main results were found, which were consistent with only one of the five hypotheses examined, the descriptive.

First, varying the amount of information available to the responder in a classical ultimatum game had an effect on both the offers made and the demands. When offers were made in dollar form, withholding information about the size of the pie from the responder produces significantly smaller offers (offers in \$U are lower than those in \$I, $p<.01$). That there is a difference between offers in these two treatments (\$I and \$U) suggests rejecting the subgame-perfect equilibrium and Ochs and Roth's minimum-absolute threshold hypothesis as descriptive theories of how preferences for fairness exhibit themselves in ultimatum games.

Second, there are significantly higher reported demands in treatment %I than in treatment %U ($p<.01$) and significantly higher rejection rates as well ($p<.05$) even though offers in the two treatments are not significantly different. This result suggests rejecting Ochs and Roth's minimum-percentage threshold hypothesis as a descriptive theory of how preferences for fairness exhibit themselves in ultimatum games.

Finally, significantly higher demands prevail when offers are made in percentages and the responder is informed (%I) than when offers are made in dollars and the responder is informed ($I). That there is a difference between responders' stated demands in the two informed treatments ($p<.01$) suggests rejecting Bolton's comparative equilibrium, along with the other three hypotheses named above. The descriptive hypothesis remains, escaping unscathed primarily because it makes no predictions about this framing effect.

One modification to Bolton's theory which would preserve its status might be found in a contingent weighting model. In such a model the weight responders place on absolute (money) payoffs as compared with relative (fairness) payoffs vary with the treatment. In particular, when the pie size is known and offers are made in percentages (%I), more weight would be placed on relative (fairness) payoffs than when the pie size is known and offers are made in dollars ($I).

There are experimental extensions of this study as well. One testable implication is the contingent weighting explanation—that the frame of the game matters seems convincing, but how much it matters, and why it matters so clearly when responders are informed but not when they are uninformed about the size of the pie, needs further investigation.

Another direction for extension involves the empirical predictions of these experimental results. That pie divisions were more fair in the classical ultimatum game than in the uninformed version of it ($I versus $U) suggests that in posted-price, monopolistic industries where sellers' costs, and thus the pie size, are known to buyers, surplus division will be more equal than in industries where those costs, and thus the pie size, are unknown or uncertain (as when consumer goods are produced by the seller). That ultimatum bargaining over percentages with known pie sizes (%I) leads to particularly high demands and high rejection rates suggests that, in cases where the pie size is known. both proposers and responders should prefer to bargain over dollar amounts.

This experiment was designed to distinguish among a number of theories of how subjects implement their preferences for fairness in bargaining games. None of the theories examined predicted all the results. The only one not rejected is the descriptive theory (primarily because it made so few predictions). A number of new experimental proposals are presented which will help us illuminate and explore some of the intricacies of strategic behavior.

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Footnotes

[1]In an ultimatum game, player one (the proposer) makes an offer to player 2 (the responder). The offer consists of a proposal dividing a sum of money (the pie or π) between the two players. Usually this offer takes the form of "player 2 can have \$x, player 1 will get \$(π-x)." Player 2 can either accept or reject the offer made. If she accepts, the pie is divided as proposed and the game ends. If she rejects, neither player receives any money, and the game also ends.

[2]The outcomes of many ultimatum game experiments and their variations are summarized in Thaler (1988), Güth and Tietz (1990) and Roth (forthcoming).

[3]Evidence that subjects in experimental games care about fairness to some extent is provided in two studies of dictator games; Forsythe *et al.* (1994) and Hoffman *et al.* (1992).

[4]The experiment was not designed to demonstrate that subject in experiments care about fairness, but rather to investigate how those preferences emerge in various situations; i.e. to answer the question, under what conditions are fairness considerations more or less important in strategic behavior?

[5]All instructions, raw data and original subject responses are available from the author.

[6]This sort of a show-up fee is standard procedure in economics experiments.

[7]This reading aloud served to make all information about who was informed and who was not, common information. Instructions, including the composite version, are available from the author.

[8]In uninformed treatments responders were never told the actual size of the pie, although they could calculate it in the %U treatment by comparing the percentage of the pie they accepted with their earnings.

[9]One reader objected strongly to this idea, claiming it is tantamount to saying that "theory X implies A=B=1 is confirmed by evidence that A=B=2 because you have confirmed A=B!" This objection is exactly correct and, had offers in the four treatments been similar, such support for the subgame-perfect hypothesis would be suspect. However, there were significant differences in behavior between the four treatments, thus the experiment confirms A$\neq$ B.

[10]If subjects use the offers they face to update their beliefs about the size of the pie, however, and those offers vary between the two uninformed treatments, then differences in those posteriors are being measured.

[11]For simplicity I am assuming here that while responders' preferences are as assumed in each theory, proposers are classical expected-utility maximizers. Entirely different sets of predictions could be generated using other assumptions about proposers' preferences (and/or other assumptions about responders' beliefs about proposers' preferences). However, given the one-sided nature of the bargaining problem, these alternative assumption do not add enough to the analysis to justify the added complexity.

[12]Here, the smallest offer possible is 1¢ which translates into an offer of .1% in the percentage treatments (for a $10 pie). Since the proposer always knows the size of the pie, this translation is simple for him to do. There is some debate as to whether the responder will accept only strictly positive offers, or if an offer of 0 will be accepted. Sometimes an alternative subgame perfect equilibrium is described, whose payoffs are $(\pi, 0)$. Actual behavior departs so radically from anything considered small that we will not dwell here on the subtleties of either the translation or the zero-offer issues.

[13]$U(z, z/(\pi-z)) \geq U(0,1)$ where the first argument of the utility function is absolute payoffs (dollars) and the second is relative payoffs (the ratio of the responder's payoff to the proposer's). A rejection which results in an allocation of (0,0) has a relative (fairness) payoff defined as 1.

[14]If the random sampling hypothesis is correct and priors are identically distributed between the uninformed treatments, and if subjects do not update their beliefs about the size of the pie as a result of the offers they face, then Bolton's equilibrium suggests that demands and offers should be identical in the two uninformed treatments as well.

[15]There is nothing in these two hypotheses requiring that the thresholds be the same across responders. If they differ, there are two alternative assumptions we can make about proposers' knowledge of the threshold. In the first, the proposer knows exactly the threshold of the responder with whom he is matched. All offers should thus be calibrated to guarantee acceptance. In the second assumption, the proposer does not know the threshold of the responder with whom he is matched, although he may know the distribution of thresholds across responders. Proposers make their expected-utility-maximizing offer given the distribution. Under this assumption, some offers may be rejected.

[16]An additional prediction which I do not test here is that offers should be for the smallest amount possible in each treatment. If some proposers have preferences for fairness and these proposers are randomly distributed in the four treatments, this latter prediction would be violated, but the prediction offered would be strengthened.

[17]The Random/Divide treatment was the one-shot ultimatum game most similar to that run in this study.

[18]Also called the Mann-Whitney U test, this test is discussed in Siegel (1956) pp. 116-126.

[19]Offers in $I are greater than those in %I ($p<.10$), offers in %I are greater than those in $U ($p<.10$) and offers in %U are greater than those in $U ($p<.10$). Comparisons between %U and $I and between %U and %I show no significant differences.

[20]The test used is based on a binomial distribution (calling an accepted offer a success and a rejected offer a failure). The test for comparing the means of two samples from a binomial distribution has a t-distribution.

[21]The questionnaire was administered after responders had made their decisions but before they were paid. Thus in the $U and %U treatments, responders did not know the true size of the pie at the time they were answering the questions discussed. In the %U treatment they did not know their dollar earnings and in the $U treatment they did not know the percentage of the pie they had accepted or rejected. This procedure can be contrasted with other studies which used the strategy method in which subject's answers to these sorts of questions were their contingent responses in the game (Güth *et al.* (1982), Kahneman *et al.* (1986), Mitzkewitz and Nagel (1993)). For an excellent discussion of the merits of the strategy method versus the decision method used in this study see Rapoport, Sundali and Seale (1993), pp. 31-32.

[22]Some of the more interesting variations include: auctioning the roles of proposer and responder (Güth and Tietz (1986)); comparing subject pools by college major (Carter and Irons (1991)), by culture (Roth *et al.* (1991)), and by sex (Eckel and Grossman (1992)); using comments as cues to behavior (Kravitz and Gunto (1992)); controlling proposer's beliefs about the responder's minimal acceptance levels (Harrison and McCabe (1992)); only using subjects who understand the subgame-perfect equilibrium (Ortona (1991)); comparing the ultimatum game with the related dictator game (Forsythe *et al.* (1994)), with the best shot public goods provision game (Prasnikar and Roth (1992)); investigating how the assignment of roles of proposer and responder and the description of the problem affects the outcome (Hoffman *et al.* (1992)); examining ultimatum games when the players' decisions are not known by the experimenter (Bolton and Zwick (1995)); and having subjects play ultimatum games in which they have to earn a minimum amount to "survive" (Schotter *et al.* (1993)).

Table 1: Treatments

		Responder's information about Pie Size: informed	Responder's information about Pie Size: uninformed
Offer made in	dollars	**$I**	**$U**
	percentage	**%I**	**%U**

Table 2: Means, Standard Deviations and Sample Sizes of Observed Offers

		Responder's information about Pie Size: informed	Responder's information about Pie Size: uninformed
Offer made in	dollars	$I $4.50 (1.07) n=28	$U $3.57 (1.56) n=26
	percentage	%I $4.20 (1.67) n=28	%U $3.92 (1.51) n=29

Table 3: P-Values for Offer Differences Between Treatments

	$U	%U	%I
$I	.0045**	.1554	.0895
$U		.0943	.0844
%U			.4682

**significant at the 1% level

Table 4: Percentage of Rejections

$I 7%	$U 4%
%I 21%	%U 3%

Table 5: Means and Standard Deviations from Questionnaire Answers

	Responder's Minimum Demand	Responder's Belief about Pie Size
$I	$2.11 (1.54)	
$U	$1.68 (1.96)	$9.10 (9.12)*
%U	$1.50 (1.58)	$7.00 (3.81)
%I	$3.23 (1.37)	

*The mean and standard deviation omitting an outlier who believed the pie to be $50 are 7.46 (3.75)

Table 6: P-Values for Reported Demands between Treatments

	$U	%U	%I
$I	.0729	.0627	.0045**
	$U	.4564	.0000**
		%U	.0001**

**significant at the 1% level

Figure 1
Ultimatum Offers $I
n=28

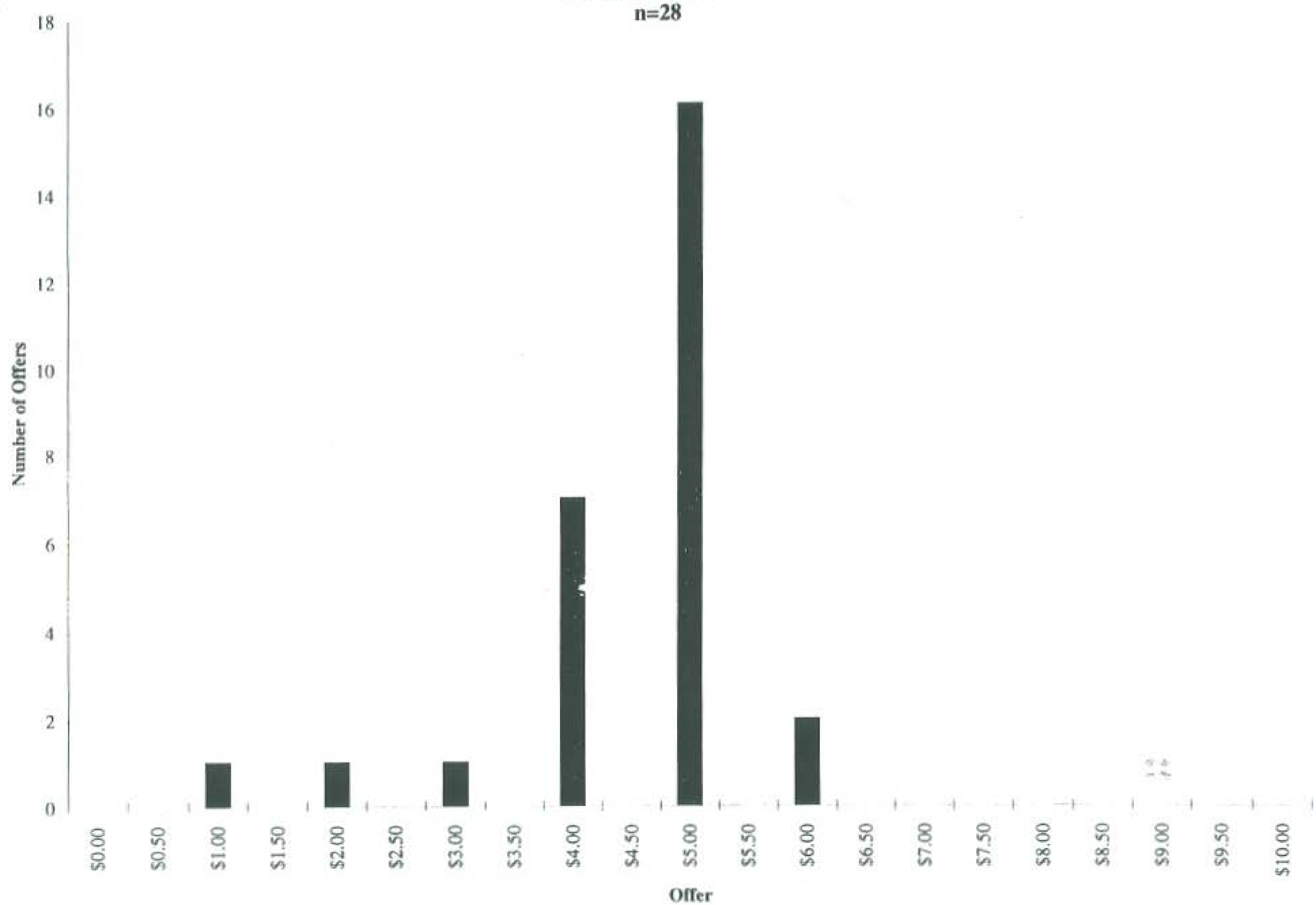


Figure 2
Ultimatum Offers $U
n=26

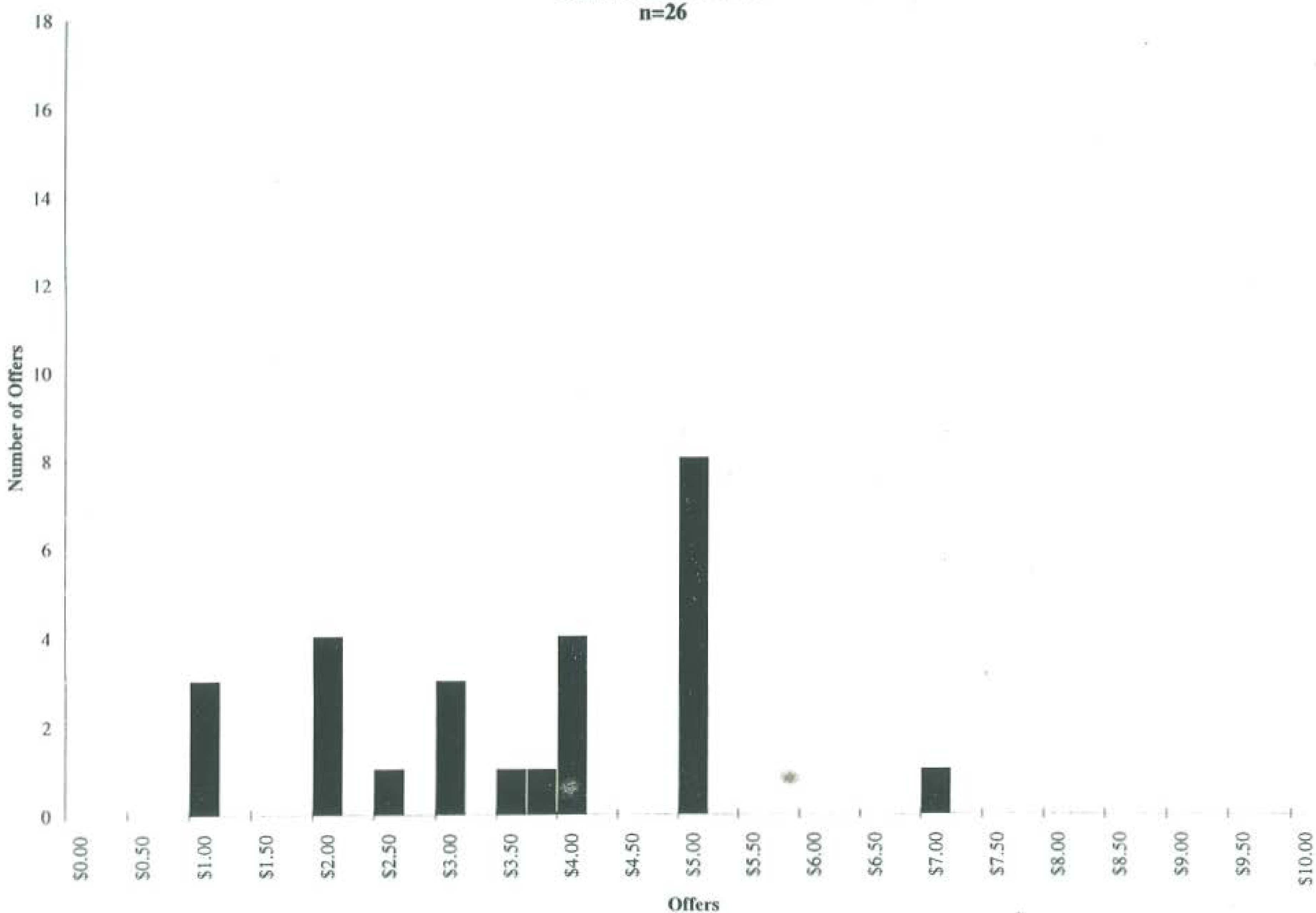


Figure 3
Ultimatum Offers %U
n=29

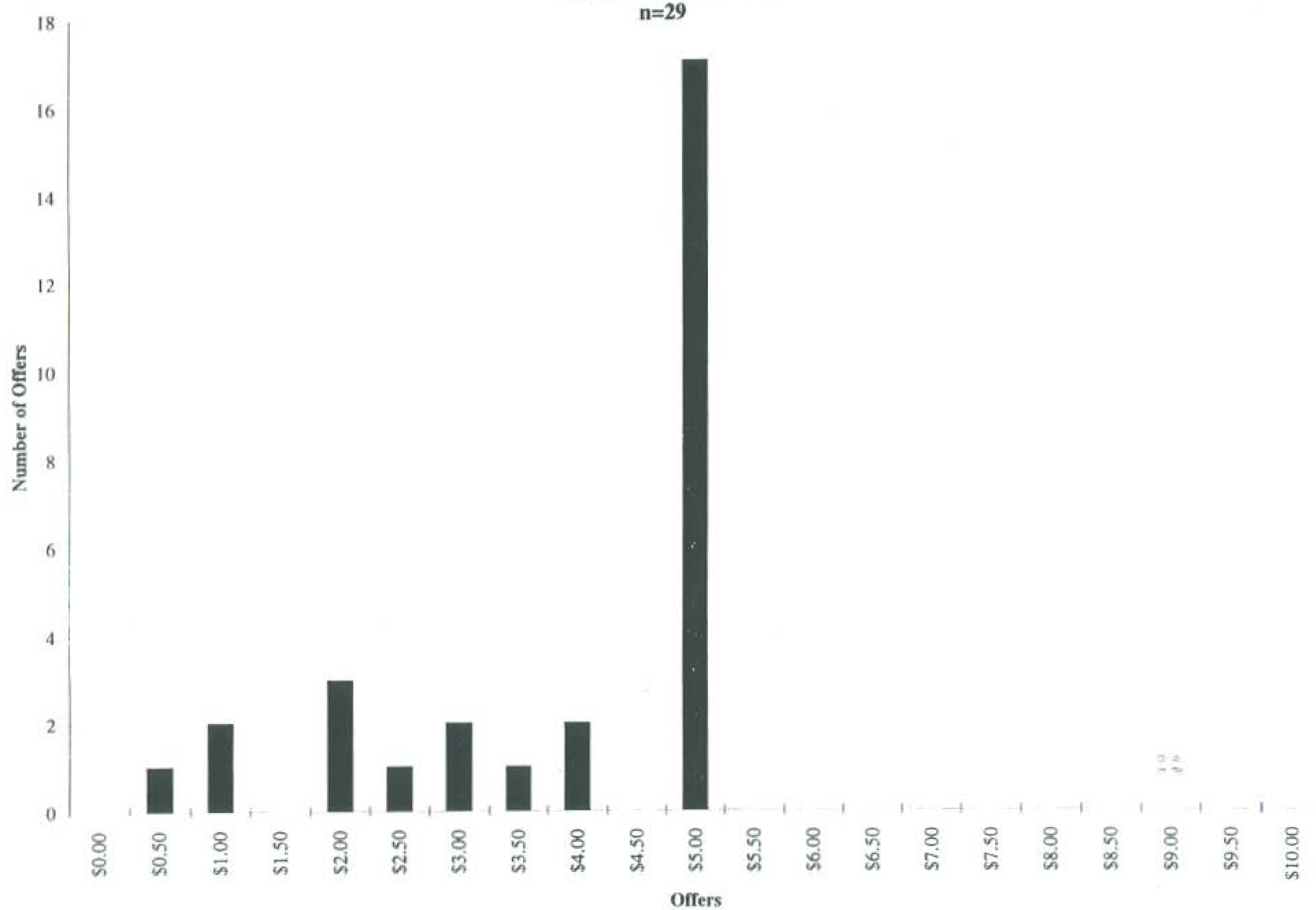


Figure 4
Ultimatum Offers %1
n=28

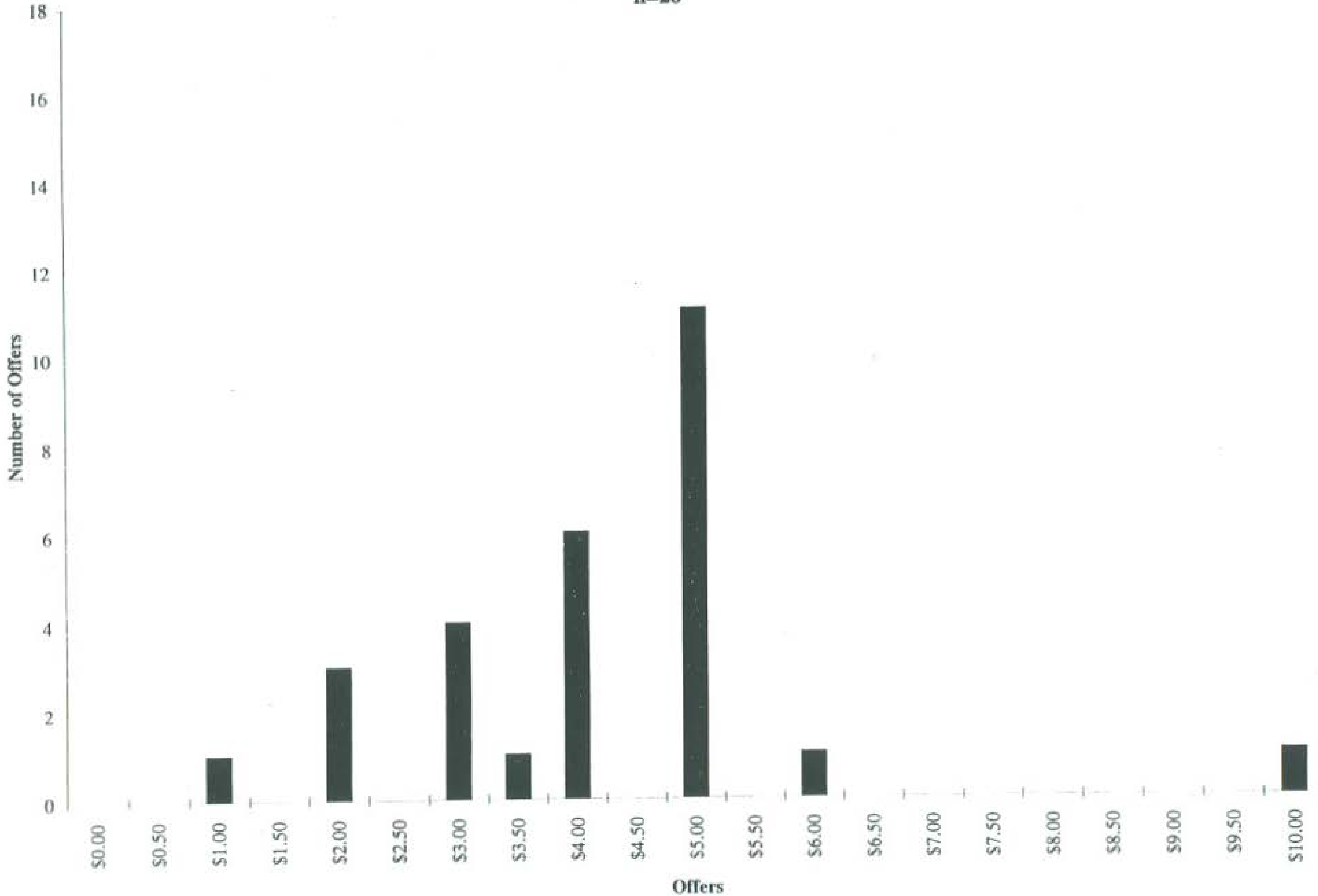


Figure 5
Reported Demands $I
n=28

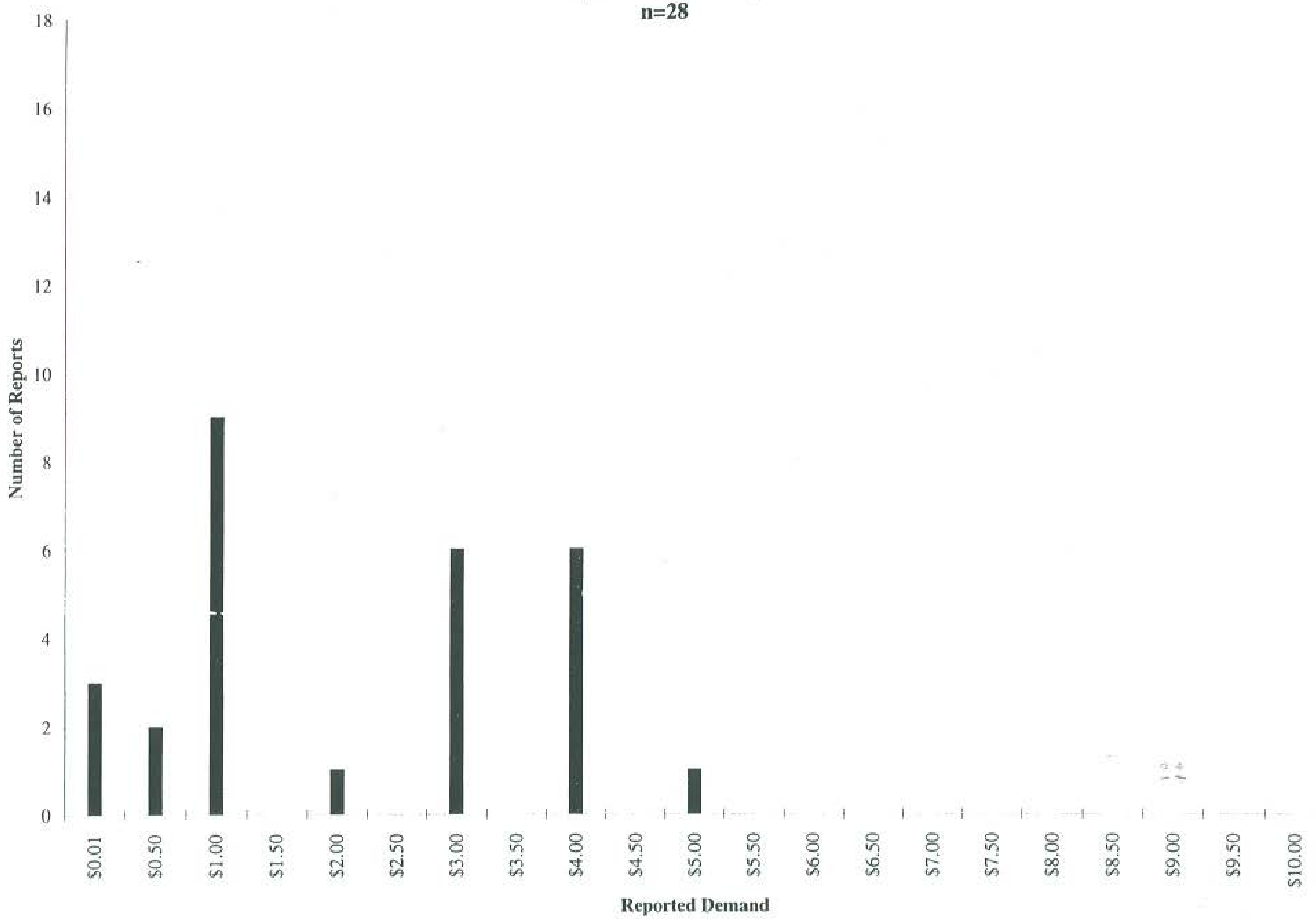


Figure 6
Reported Demands $U
n=29

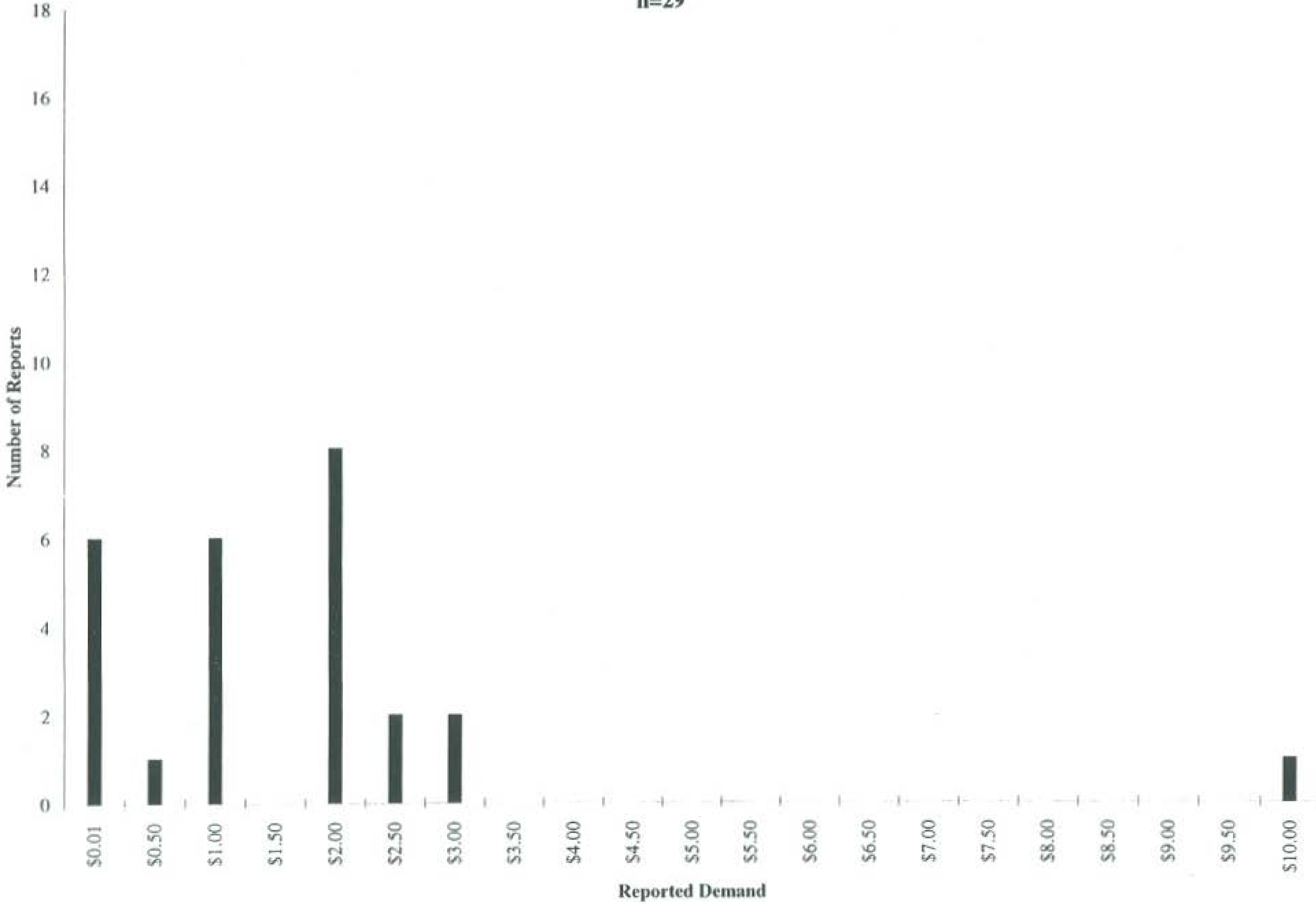


Figure 7
Reported Demands %U
n=26

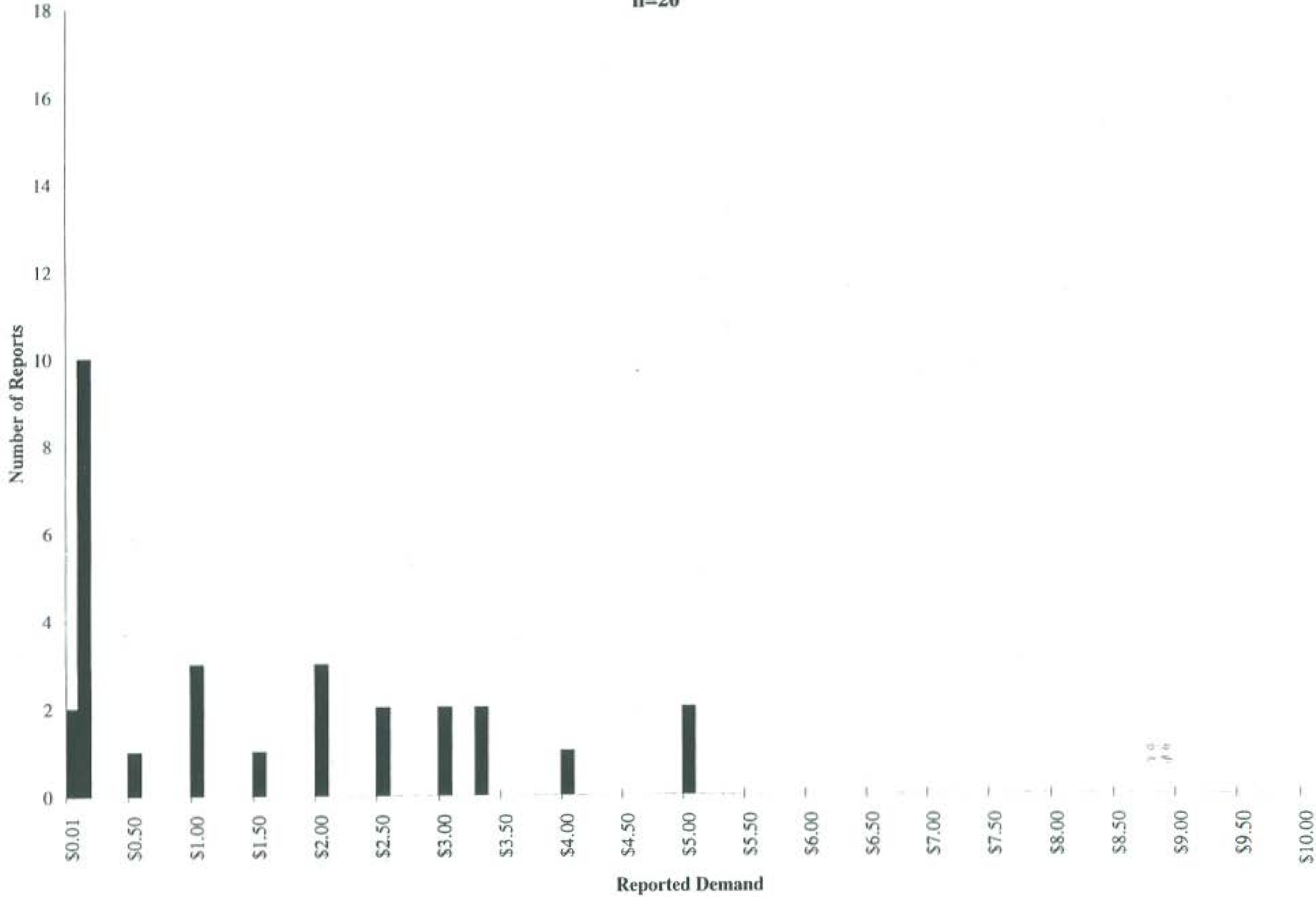
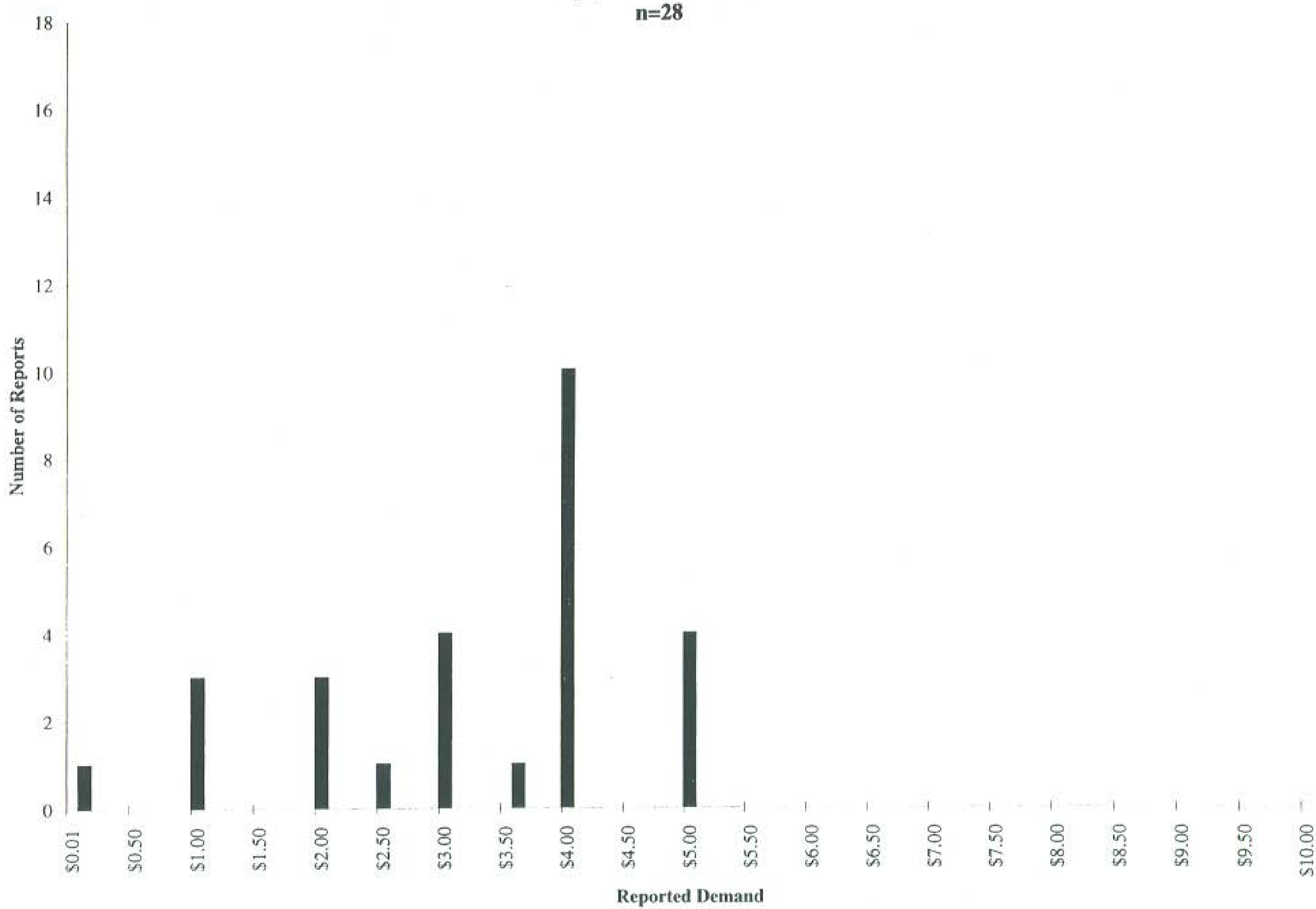


Figure 8
Reported Demands %1
n=28



Appendix: Instructions

A. Instructions and questionnaires for $I

B. Instructions and questionnaires for $U

C. Instructions and questionnaires for %U

D. Instructions and questionnaires for %I

E. Composite instructions

A. Instructions and questionnaires for $I

PLAYER ID __________

You are player 1. You and a randomly assigned player 2 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. You may offer some amount of the money (less than or equal to the amount in the pot) to player 2. If he accepts the offer, you get the pot minus the amount you offered, while player 2 receives the amount you offered. If he refuses the offer, you both get no money; the pot returns to the experimenter. Both you and player 2 know the amount of money in the pot.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: The pot is \$X. You offer \$Y to player 2. ($X \geq Y$)

A: Player 2 accepts. Player 2 receives \$________, you receive \$_________.

B: Player 2 refuses. Player 2 receives \$________, you receive \$_________.

Any questions?

The pot contains \$10. You will now offer some amount of the pot to player 2. Take as much or as little time as you like to decide. Once you have decided on your offer, write it in the appropriate place on the next page. We will communicate your offer to the appropriate player 2, who will respond on the same form. We will then pay you and player 2 any money which you have earned. At no time will player 2 know your identity, nor will you know his.

OFFER AND RESPONSE FORM

PLAYER ID __________

I, Player 1, offer Player 2 $________________.

PLAYER ID __________

I, Player 2, accept / reject Player 1's offer. (circle one)

PLAYER ID ________.

SUPPLEMENTAL QUESTIONS FOR PLAYERS 1

1. How did you decide what amount to offer?

2. Before player 2 responded, what did you think was the lowest offer that he would have accepted?

3. How did you arrive at that number?

4. After player 2 responded, what did you think was the lowest offer that he would have accepted?

5. How did you arrive at that number?

PLAYER ID __________

You are player 2. You and a randomly assigned player 1 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. Player 1 will offer some amount of the pot to you. If you accept the offer, player 1 gets the pot minus the amount he offered to you, while you receive the amount offered to you. If you refuse the offer, you both get no money; the pot returns to the experimenter. Both you and player 1 know the amount of money in the pot.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: The pot is $X. Player 1 offers $Y to you. ($X \geq Y$)

A: You accept. You receive $________, player 1 receives $_________.

B: You refuse. You receive $________, player 1 receives $_________.

Any questions?

The pot contains $10. Players 1 will now make their offers. Once that has occured, we will communicate to you the offer of the appropriate player 1, and you will accept or refuse the offer. Take as much or as little time as you like to decide. We will then pay you and player 1 any money which you have earned. At no time will player 1 know your identity, nor will you know his.

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 2

1. What was the lowest offer from player 1 you would have accepted?

2. How did you arrive at that number?

B. Instructions and questionnaires for $U

PLAYER ID ________.

You are player 1. You and a randomly assigned player 2 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. You may offer some amount of the money (less than or equal to the amount in the pot) to player 2. If he accepts the offer, you get the pot minus the amount you offered, while player 2 receives the amount you offered. If he refuses the offer, you both get no money; the pot returns to the experimenter. Only you know the amount of money in the pot, that is, player 2 DOES NOT know the amount of money available to be divided.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: The pot is \$X. You offer \$Y to player 2. $(X \geq Y)$

A: Player 2 accepts. Player 2 receives \$________, you receive \$_________.

B: Player 2 refuses. Player 2 receives \$________, you receive \$_________.

Any questions?

The pot contains \$10. You will now offer some amount of the pot to player 2. Take as much or as little time as you like to decide. Once you have decided on your offer, write it in the appropriate place on the next page. We will communicate your offer to the appropriate player 2, who will respond on the same form. We will then pay you and player 2 any money which you have earned. At no time will player 2 know your identity, nor will you know his. REMEMBER THAT PLAYER 2 DOES NOT KNOW THE AMOUNT OF MONEY IN THE POT.

OFFER AND RESPONSE FORM

PLAYER ID __________

I, Player 1, offer Player 2 $________________.

PLAYER ID __________

I, Player 2, accept / reject Player 1's offer. (circle one)

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 1

1. How did you decide what amount to offer?

2. Before player 2 responded, what did you think was the lowest offer that he would have accepted?

3. How did you arrive at that number?

4. After player 2 responded, what did you think was the lowest offer that he would have accepted?

5. How did you arrive at that number?

6. What do you think player 2 believed about the size of the pot? How big do you think he thought it was? How certain do you think he was about his guess?

PLAYER ID __________

You are player 2. You and a randomly assigned player 1 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. Player 1 will offer some amount of the pot to you. If you accept the offer, player 1 gets the pot minus the amount he offered to you, while you receive the amount offered to you. If you refuse the offer, you both get no money; the pot returns to the experimenter. Only player 1 knows the amount of money in the pot, in particular, you DO NOT know the amount of money available to be divided.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: You do not know the amount in the pot. Player 1 offers $Y to you.

A: You accept. You receive $________, player 1 receives $_________.

B: You refuse. You receive $________, player 1 receives $_________.

Any questions?

You do not know the amount of money in the pot. Players 1 will now make their offers. Once that has occured, we will communicate to you the offer of the appropriate player 1, and you will accept or refuse the offer. Take as much or as little time as you like to decide. We will then pay you and player 1 any money which you have earned. At no time will player 1 know your identity, nor will you know his.

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 2

1. Before you saw Player 1's offer, what was your best estimate of the size of the pot?
   How certain were you of this estimate?

2. What was the lowest offer from player 1 you would have accepted?

3. How did you arrive at that number?

4. After you saw player 1's offer, what was your best estimate of the size of the pot?
   How certain were you of this estimate?

5. Did the lowest offer you would accept change as a result of player 1's offer?
   In what way and why?

C. Instructions and questionnaires for %U

PLAYER ID __________

You are player 1. You and a randomly assigned player 2 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. You may offer some percentage of the money (from 0% to 100%) to player 2. If he accepts the offer, you get the pot minus what you offered, while player 2 receives what you offered. If he refuses the offer, you both get no money; the pot returns to the experimenter. Only you know the amount of money in the pot, that is, player 2 DOES NOT know the amount of money available to be divided.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: The pot is $X. You offer Y% to player 2.

A: Player 2 accepts. Player 2 receives $________, you receive $_________.

B: Player 2 refuses. Player 2 receives $________, you receive $_________.

Any questions?

The pot contains $10. You will now offer some percentage of the pot to player 2. Take as much or as little time as you like to decide. Once you have decided on your offer, write it in the appropriate place on the next page. We will communicate your offer to the appropriate player 2, who will respond on the same form. We will then pay you and player 2 any money which you have earned. At no time will player 2 know your identity, nor will you know his. REMEMBER THAT PLAYER 2 DOES NOT KNOW THE AMOUNT OF MONEY IN THE POT.

OFFER AND RESPONSE FORM

PLAYER ID __________

I, Player 1, offer Player 2 _______________% of the pot.

PLAYER ID __________

I, Player 2, accept / reject Player 1's offer. (circle one)

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 1

1. How did you decide what percentage to offer?

2. Before player 2 responded, what did you think was the lowest offer that he would have accepted?

3. How did you arrive at that number?

4. After player 2 responded, what did you think was the lowest offer that he would have accepted?

5. How did you arrive at that number?

6. What do you think player 2 believed about the size of the pot? How big do you think he thought it was? How certain do you think he was about his guess?

PLAYER ID __________

You are player 2. You and a randomly assigned player 1 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. Player 1 will offer some percentage of the pot to you (from 0% to 100%). If you accept the offer, player 1 gets the pot minus what he offered to you, while you receive what he offered to you. If you refuse the offer, you both get no money; the pot returns to the experimenter. Only player 1 knows the amount of money in the pot, in particular, you DO NOT know the amount of money available to be divided.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: You do not know the amount in the pot. Player 1 offers Y% to you.

A: You accept. You receive $________, player 1 receives $_________.

B: You refuse. You receive $________, player 1 receives $_________.

Any questions?

You do not know the amount of money in the pot. Players 1 will now make their offers. Once that has occured, we will communicate to you the offer of the appropriate player 1, and you will accept or refuse the offer. Take as much or as little time as you like to decide. We will then pay you and player 1 any money which you have earned. At no time will player 1 know your identity, nor will you know his.

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 2

1. Before you saw Player 1's offer, what was your best estimate of the size of the pot?
   How certain were you of this estimate?

2. What was the lowest offer from player 1 you would have accepted?

3. How did you arrive at that number?

4. After you saw player 1's offer, what was your best estimate of the size of the pot?
   How certain were you of this estimate?

5. Did the lowest offer you would accept change as a result of player 1's offer?
   In what way and why?

D. Instructions and questionnaires for %I

PLAYER ID _________.

You are player 1. You and a randomly assigned player 2 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. You may offer some percentage of the money (from 0% to 100%) to player 2. If he accepts the offer, you get the pot minus what you offered, while player 2 receives what you offered. If he refuses the offer, you both get no money; the pot returns to the experimenter. Both you and player 2 know the amount of money in the pot.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers

AN EXAMPLE: The pot is $X. You offer Y% to player 2.

A: Player 2 accepts. Player 2 receives $________, you receive $_________.

B: Player 2 refuses. Player 2 receives $________, you receive $_________.

Any questions?

The pot contains $10. You will now offer some percentage of the pot to player 2. Take as much or as little time as you like to decide. Once you have decided on your offer, write it in the appropriate place on the next page. We will communicate your offer to the appropriate player 2, who will respond on the same form. We will then pay you and player 2 any money which you have earned. At no time will player 2 know your identity, nor will you know his.

OFFER AND RESPONSE FORM

PLAYER ID __________

I, Player 1, offer Player 2 _______________% of the pot.

PLAYER ID __________

I, Player 2, accept / reject Player 1's offer. (circle one)

PLAYER ID ________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 1

1. How did you decide what percentage to offer?

2. Before player 2 responded, what did you think was the lowest offer that he would have accepted?

3. How did you arrive at that number?

4. After player 2 responded, what did you think was the lowest offer that he would have accepted?

5. How did you arrive at that number?

E. Composite instructions

PLAYER ID __________

You are player 1 or 2. You and a randomly assigned player of the opposite number have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. Player 1 will offer some amount of the pot to player 2. If player 2 accepts the offer, player 1 gets the pot minus the amount he offered, while player 2 receives the amount offered. If player 2 refuses the offer, both players get no money; the pot returns to the experimenter. *(if known treatment)* Both players 1 and 2 know the amount of money in the pot. *(if unknown treatment)* Only player 1 knows the amount of money in the pot, in particular, player 2 does not know the amount of money available to be divided.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: *(if known treatment)* The pot is \$X. Player 1 offers \$Y *(if percentage treatment* Y%) to player 2. *(if unknown treatment)* On player 1's instruction sheets it says the amount of money in the pot for this example only. On player 2's instruction sheet it will remind you that you do not know the amount of money in the pot. Player 1 offers \$Y *(if percentage treatment* Y%) to player 2.

A: Player 2 accepts. Player 2 receives \$________, player 1 receives \$________.

B: Player 2 refuses. Player 2 receives \$________, player 1 receives \$________.

Any questions?

(if known treatment) There is \$10 in the pot. *(if unknown treatment)* At this point, players 1 instructions include the amount of money in the pot and players 2 are reminded that they do not know the amount of money in the pot. Players 1 will now make their offers. Once that has occurred, we will communicate to player 2 the offer of the appropriate player 1, and that player 2 will accept or refuse the offer. Take as much or as little time as you like to decide. We will then pay both player 2 and player 1 any money which you have earned. At no time will player 1 know player 2's identity, nor will player 2 know player 1's. *(if unknown treatment)* Remember that player 2 does not know the amount of money in the pot available to be divided.

PLAYER ID __________

You are player 2. You and a randomly assigned player 1 have an opportunity to earn some money.

There is a "pot" of money which the experimenter has set aside. Player 1 will offer some percentage of the pot to you (from 0% to 100%). If you accept the offer, player 1 gets the pot minus what he offered to you, while you receive what he offered to you. If you refuse the offer, you both get no money; the pot returns to the experimenter. Both you and player 1 know the amount of money in the pot.

To be sure you understand the procedure, fill in the blanks in the example below and wait for someone to check your answers.

AN EXAMPLE: The pot is $X. Player 1 offers Y% to you.

A: You accept. You receive $________, player 1 receives $_________.

B: You refuse. You receive $________, player 1 receives $_________.

Any questions?

The pot contains $10. Players 1 will now make their offers. Once that has occured, we will communicate to you the offer of the appropriate player 1, and you will accept or refuse the offer. Take as much or as little time as you like to decide. We will then pay you and player 1 any money which you have earned. At no time will player 1 know your identity, nor will you know his.

PLAYER ID __________

SUPPLEMENTAL QUESTIONS FOR PLAYERS 2

1. What was the lowest offer from player 1 you would have accepted?

2. How did you arrive at that number?