Changing endowment sizes and prices of giving in ultimatum games

Kevin Haas*

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Abstract

This paper looks at a rich data set that was generated from ultimatum games where the players were faced with changing endowments and prices of giving. The results from this experiment are graphically summarized and explored below. In the conclusion I outline a possible next step towards constructing a model of Proposer behavior in the ultimatum game.

1 Introduction

My paper looks at data that was generated by ultimatum games; however, unlike traditional ultimatum games, individuals play the game fifty times and each time they are faced with different endowment sizes and prices of giving[1]. Thus there is a breadth of data on the individual, which allows for more differentiation between players.

Changing the endowment size and price of giving was first implemented by James Andreoni and John Miller in (2002) to see if preferences for altruism are consistent with a well-behaved preference ordering. We use changing endowment size and prices of giving

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1 Price of giving refers to the value of the tokens for the Proposer and Responder. Traditionally these values are the same, but in this data set they typically are not.

to create a richer data set and to more accurately capture the various ultimatum game strategies that exist. We find that similar strategies in the traditional ultimatum game may come from participants with very different social preferences and our data set allows us to differentiate between these individuals.

The analysis begins by looking at the distribution of payoffs to see how the Proposers and Responders as a group reacted to changes in the price of giving (price). We compare the behavior of Proposers to other experimental outcomes of the ultimatum game and find them to be consistent. The distributions are interesting because they allow us to immediately see that behavior in the ultimatum game is quite heterogeneous for both Proposers and Responders.

Then we look at the individual responses of Proposers and Responders for all fifty trials. For the Proposers we see that there are some common strategies and group these individuals accordingly. Responder behavior is different and more difficult to classify as we see that there are many more strategies. There is not enough data on Responders for common trends to emerge or to easily group them. Examples are provided for both player types to graphically illustrate their behavior.

By having Responders divulge their reservation price we can create a measure of efficiency: the demand spread. Efficiency refers to how close the Proposer and Responder are from a Nash equilibrium[2] and the demand spread measures this distance. We will see from the graphs that as the price of giving increases there is more inefficiency.

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[2] Nash Equilibrium in the ultimatum game occurs when both players select equivalent divisions as a deviation from this point will cause one player to have a reduced payoff or even no payoff.

Finally, I will end by looking at the problem of heterogeneity and how it impedes the creation of a model of ultimatum game behavior. This has been an issue because it is difficult to differentiate between the social preferences of the individual, the Proposer's fear of being rejected and human error. I will also outline the next step towards creating this model.

2 Background

The first experimental evidence for the ultimatum game comes from the Güth et al in 1982. This study sought to test whether individuals behaved according to the predicted subgame perfect equilibrium. The ultimatum game has one subgame perfect equilibrium where the Proposer offers some small epsilon[3], which allows the Proposer to maximize their own payoff. The responder will immediately accept because epsilon is greater than zero, which yields a higher payoff than rejecting the offer. Güth et al found that Proposers generally made offers between forty and fifty percent of the total endowment, which is greater than zero and much larger than epsilon. They saw that Responders also deviated from subgame perfect equilibrium as they rejected offers that were greater than zero. Their conclusion was that the fairness of an offer matters and that Responders "do not hesitate to punish their opponent" if they act unfairly.[4]

The fairness of an offer in the ultimatum game became a consideration because if a Proposer were to play according to the subgame perfect equilibrium they would find their offer getting rejected most of the time. Camerer put the game and Responder behavior in the following context: "The ultimatum game is an instrument for asking Responders 'Is this offer fair?' It forces them to put their money where their mouth is and

[3] Epsilon refers to an infinitesimally small, but positive amount.
[4] Güth et al (1982)

reject offers they claim are unfair."[5] Thus incorporating fairness into a model of ultimatum game behavior became important because it was clear that subjects did not behave according to what economists had initially postulated.

An important, general model of fairness for game theory is developed in Rabin (1993). Because "people like to help those who are helping them, and to hurt those who are hurting them" Rabin was able to define the concept of fairness equilibrium.[6] Fairness equilibrium is dependent on the size of the payoffs, but occurs when an outcome is either mutual-max or mutual-min Nash equilibrium. A mutual-max outcome is where both players are maximizing the others material payoffs and a mutual-min is when both players are minimizing the others material payoffs. The model differs in that it incorporates the beliefs of players as well as their actions and payoffs. So for a game with two players, the model will factor in what the first player believes the second player will do.

Fairness helps to dictate whether a Responder accepts or rejects an offer, which in turn forces the Proposer to make an offer that they perceive as fair. But Proposers are heterogeneous in their social preferences and what one Proposer considers fair may be inconsistent with another's beliefs. This is because different Proposers have different social preferences, which capture their attitudes towards fairness. Charness and Rabin (2002) develop an important model of social preferences for two person games. They did this through devising numerous simple games and looking at players' actions and responses. The definitions of the social preferences in this paper are important for our analysis and categorization of Proposer behavior.

[5] Camerer, Colin (1997), pp. 169
[6] Rabin, Mathew (1993), pp.1281

> **Competitive Preferences** Where Player A prefers to do as well as possible in comparison to the other player, while also caring about their own payoff.
>
> **Difference Aversion** Where players prefer payoffs to be equal and will seek to reduce the payoffs of others when they are larger than their own.
>
> **Social-Welfare Preferences** Subjects prefer more for themselves and more for the other players, but are more in favor of getting payoffs for themselves when they are behind than when they are ahead.

A simplified version of the ultimatum game is to revoke the Responders ability to reject an offer. Thus the Proposers "dictates" a division of payoffs to himself (*self*) and to the now voiceless Responder (*other*). Dictator games are useful in the study of ultimatum games as it makes it possible to look at the social preferences of an individual without trying to account for fear of rejection or error.

Andreoni and Miller (2002) study dictator games with changing endowments and prices of giving to see if their subjects have utility functions that are continuous, convex and monotonic. They use the axioms of revealed preferences to test for rationality and then they estimate their subjects' individual preferences, which are based upon the social preferences of each participant. An important conclusion of this paper is that subjects are quite heterogeneous and that any model that wants to capture fairness and altruism must account for this.

Fisman, Kariv and Markovits (2007) also look at dictator games with changing endowments and prices of giving, but their subjects make their divisions over budget lines on a graphical interface. They also include step-wise budget lines so that the individuals who dictate the division are faced with extreme prices of giving. They test for consistency and rationality using the axioms of revealed preferences and estimate their corresponding utility functions. The three person games allow them to look at the relationship between social preferences and distributional preferences[7]. Their findings support the idea of subject heterogeneity when it comes to individual preferences, but that subjects distributional preferences are similar at least when contrasting efficiency and equity.

3 Experimental Design

The data from this study was taken from pilot studies conducted at Princeton University. Two different sessions were conducted each with 16 people for a total of 32 subjects. At the beginning each person was randomly assigned by a computer to act as either a Proposer or a Responder throughout the entire experiment. The instructions provided at the beginning of each session outlined the rules of the game, payoff structure and defined the Proposer and Responder roles.

Every subject then participated in fifty rounds of the ultimatum game where they were faced with varying endowments and prices of giving. All fifty trials were completed on a two-dimensional graphical interface, as shown in Appendix I, where the participant was faced with a budget line and was instructed to choose a point within the budget. The point chosen by Proposers represented the payoff to the Proposer and the portion offered to the Responder. Responders chose their points based on their reservation price[8]. At the beginning of each trial, the participants were randomly paired up with a member of the opposite type; however, they were never informed of the outcome chosen by their

[7] Fisman, Kariv and Markovits make an important distinction between social preferences and distributional preferences. Social preferences are how *self* distinguishes between his own payoffs the payoffs given to *others* while distributional preferences are how *self* distinguishes between the payoffs of *others*.
[8] The minimum amount needed for them to accept the offer. Sometimes referred to minimum fraction demanded.

counterpart. This was done to preserve the one-shot nature of the game and prevent confounds from feedback and experience.

Subjects were informed of the structure of the payoffs at the beginning of the experiment but were paid at the end after all decision rounds had been completed. Each subject was given a $10 participation fee and a $2 fee for completing a short exit survey. Participants received an additional payment based on the outcome of one randomly selected round. The instructions, which can be seen in Appendix I, were explicit in emphasizing that money was at stake based on the outcome of the game and that a rejected offer would lead to lower total payoffs.

4 Results

4.1 Proposers

I will start by looking at the Proposers as a group. The data tells us the division selected by the Proposer, the Proposer max[9] and the Responder max[10]. To get the price of giving I divide the Proposer max by the Responder max. The first graph looks at the distribution of what fraction of the endowment each Proposer kept for themselves over all prices.

[Insert figure 1]

Camerer (1997) states that [Proposers] typically offer 40-50 percent of X, where X is the size of the endowment. The graph above shows that Proposers from this study act consistently with Camerer's (1997) prediction as over 50% of all trials have Proposers

[9] Proposer max refers to maximum payoff the Proposer could receive by allocating all tokens to himself and none to the Responder.
[10] Responder max refers to the maximum payoff the Responder could receive if the Proposer got no tokens.

keeping 50-60% for themselves, which translates into an offer of 40-50%. The distribution of all prices does have a non-trivial right tale, but this can be attributed to Proposers who are faced with high prices of giving, which makes it cheaper to hold onto tokens. This behavior is interesting because one might expect the distribution to mirror this effect when prices of giving are low, which makes it cheaper to give away tokens. However, when faced with low prices, Proposers as a whole keep at least 40% of the endowment in 78% of the rounds and keep at least 50% of the endowment in more than half of the rounds. Thus when looking at Proposers as a whole the fraction of the endowment they keep increases as prices rise i.e. as it gets more expensive to pass tokens.[11]

[Insert figure 2]

[Insert figure 3]

Now looking at Proposers individually we see that they are heterogeneous in their response to changing prices, but we are able to find some similarities amongst them. Within our data there appears to be three main types of Proposers. The Proposer depicted in Figure 4 represents Proposers where the fraction that they offer does not change as the price changes. These Proposers appear to have social preferences consistent with difference aversion. These Proposers, which represent 12.5% of all Proposers or two in our data, offer a split of exactly half the tokens every round.

[Insert figure 4]

The next group of Proposers, depicted in Figure 5, is those who change the fraction that they keep for themselves based on price. So when it is cheaper to pass

[11] "Low prices" refers to a price of giving where it is cheap to offer tokens to the Responder. Vice versa, "high prices" refers to a price of giving where it is expensive to offer tokens to the Responder.

tokens they will keep a smaller fraction for themselves and vice versa when it is expensive to pass tokens they keep a larger portion for themselves. The social preferences of these Proposers are similar to social-welfare preferences. There are 5 of these Proposers in our data set, which makes up 31.25% of all Proposers. It is interesting to note that in the standard ultimatum game where log price is always equal to 0 (or price of giving equal to 1), the Proposers shown in Figures 4 and 5 would look exactly the same. But as you can see, by varying price we realize that they behave very differently. It is important to differentiate between these two Proposers as it is clear they have different social preferences. This shows us conclusions from standard ultimatum games rely on simplified knowledge of the participants instead of incorporating the full diversity of the participants.

[Insert figure 5]

Another four Proposers, 25% of all Proposers, appear to have behavior that is a combination of the two strategies above. When it is relatively cheap to give tokens, they offer a constant fraction of the endowment and do not vary their offer with price. However, once it becomes expensive to give tokens they begin to keep a larger fraction for themselves so that when it is very expensive to keep tokens they are keeping a large fraction of the endowment. It is more difficult to classify the social preferences of these Proposers as they could be either of the social preferences listed above or a completely different one. Figure 6 is a good example of this type of Proposer.

[Insert figure 6]

4.2 Responders

Now we turn our attention to Responders. The Responders were asked to give us their reservation price for each endowment size and price of giving. Because the Responder portion of the experiment was conducted in this way, instead of just responding to the Proposer's division, we have data for each Responder in every trial.

[Insert figure 7]

Responders, as a whole, do not vary their reservation price with the price of giving. This can be seen as 95% of all divisions chosen lie between zero and half of the endowment. There are only a few Responders who demand larger than half of the endowment and almost all of these are from trials where the price of giving is low. When the price of giving is high, these divisions are non-existent.

When looking at the distribution, there are a lot of offers close to and at 0, which suggests that some Responders are implementing strategies that are consistent with subgame perfect equilibrium. It is interesting to note that all of these offers can be attributed to three Responders or 18.8% of all Responders who are shown in Figure 8. There are an additional two, or 12.5% of all Responders, who have low, but non-zero reservation prices that are less than 15% of the total endowment. These Responders are ensuring that they get some payoff in most trials, but are not satisfied with the subgame perfect equilibrium as they reject epsilon.

[Insert figure 8]

Another group of Responders are those that have a constant reservation price that is independent of the changing price of giving. The minimum fraction demanded changes from Responder to Responder, but all are less than or equal to 50% of the endowment. These Responders are graphed in Figure 9 and account for four of the total Responders (25%).

[Insert figure 9]

The remaining Responders are more difficult to classify as they are quite heterogeneous. They all vary the amount they demand by price. Some change the amount they demand by price over all prices while others will only vary the amount demanded when prices are either favorable or unfavorable to them and constant otherwise. These groups of Responders do not appear as distinguished as the two mentioned above; however, this may be a side effect of a small data set. These “types” of Responders may appear more prominent in a larger data set, but Responders as a whole have many different strategies.

4.3 Demand Spread and Nash Equilibrium

The ultimatum game only has one subgame perfect equilibrium, but it contains many Nash equilibria. By definition Nash equilibrium is any point where no player can deviate and receive higher payoffs. In the ultimatum game this is true anytime the Proposer and the Responder choose the same division because a deviation will either lower their payoffs or cause the offer to be rejected, which results in zero payoffs for both players. However, Nash Equilibrium rarely occurs and in our data only 3.5% of the trials were Nash Equilibrium. The demand spread will summarize how close each trial comes to achieving Nash Equilibrium.

[Insert figure 10]

The distribution above shows the demand spread for all trials and all prices. There is small clustering of points within a few points of zero, but there is a large right tale. The positive values signify that the Proposer offered an amount larger than the amount demanded by the Responder while the negative values represent offers that were rejected because the Proposer offered too little. This graph shows that there is a lot of inefficiency and a lot of it comes from Proposers offering too much. In fact, Proposers on average offer 17 tokens above Nash Equilibrium and the ratio of overbidding to underbidding is 4 to 1.

[Insert figure 11]

[Insert figure 12]

However it is understandable that Proposers offer too much more often then they offer too little. This comes about because of the design of the game as the cost of being rejected is very high. A small mistake will lead to a payoff of zero and many Proposers seek to avoid this since they know Responders do not accept all positive offers. Also, Proposers do not know the social preferences of Responders or how they will react to certain offers. Responders are a very heterogeneous group and their reserve prices range from 0 to 50% of the offer making it difficult to predict which reserve price you may be facing. To illustrate this, the most typical common offer of 40%-50% will get rejected some of the time, but can also lead to large inefficiencies if the Responder has a reservation price of zero.

The two graphs above show how the demand spread changes when prices switch from low to high. The distributions show us that there is more inefficiency when prices are higher. This occurs because there is greater variation in the offer size of the Proposer and greater variation in the reservation of the Responder when the price of giving is high. Proposer offers range from 50% to 90% of the endowment, while reservation prices also vary from 0% to 50%. This can be seen in the third distribution where we look at how much the Proposer keeps for them when the price of giving is high.

5 Conclusion

Proposers in our data set act consistently with Proposers in other ultimatum game experiments as they typically offer 40-50% of the endowment. Also, we were able to classify most of the Proposers based on their social preferences because our participants faced changing endowments and prices of giving. This allowed us to see the heterogeneous nature of the Proposers and that their perceptions of fairness vary at the individual level.

We also find that Proposers account for the fact that the Responders are a heterogeneous group themselves. This can be seen when looking at the demand spread distributions where Proposers typically offer more than what is needed for the Responder to accept the offer. This leads to large inefficiencies in the game where Proposers are offering more then they should because they fear rejection.

Responder heterogeneity can easily be seen in the data as we were only able to group nine of the sixteen Responders by their similar strategies. The other seven Responders occupy a large range of behavior where a larger data set is needed to see if any of these behaviors become more prominent. Because of this, it makes it difficult for Proposers to reduce the inefficiency of their offers as there are so many types of Responders they could be facing. Instead, they must over-compensate the Responder so that they reduce their chances of having their offer rejected and receiving no payoff.

With this in mind, it becomes apparent that a model of ultimatum game behavior based on an "average" player will not work because there is no such thing as an "average" ultimatum game player. One difficulty in modeling ultimatum game behavior is differentiating between a Proposer's social preferences and their fear of rejection. Fear of rejection arises because the costs of being rejected are so high that it is cost effective for the Proposer to pay some "insurance" (i.e. larger offer) to avoid being rejected. Figuring out the size of this insurance is difficult and can be confounded by error as there is no guarantee against rejection. This is one avenue of research that can be looked at in the data set above and which will help in creating a model.

To address this problem I believe that further research is needed. To determine the effect of an individual's social preferences and risk preferences the players of the modified ultimatum game should also play the dictator game as well as a third game to determine risk preferences. If these experiments allow us to differentiate between a person's social preferences and their fear of rejection, then it might be possible to model Proposer behavior.

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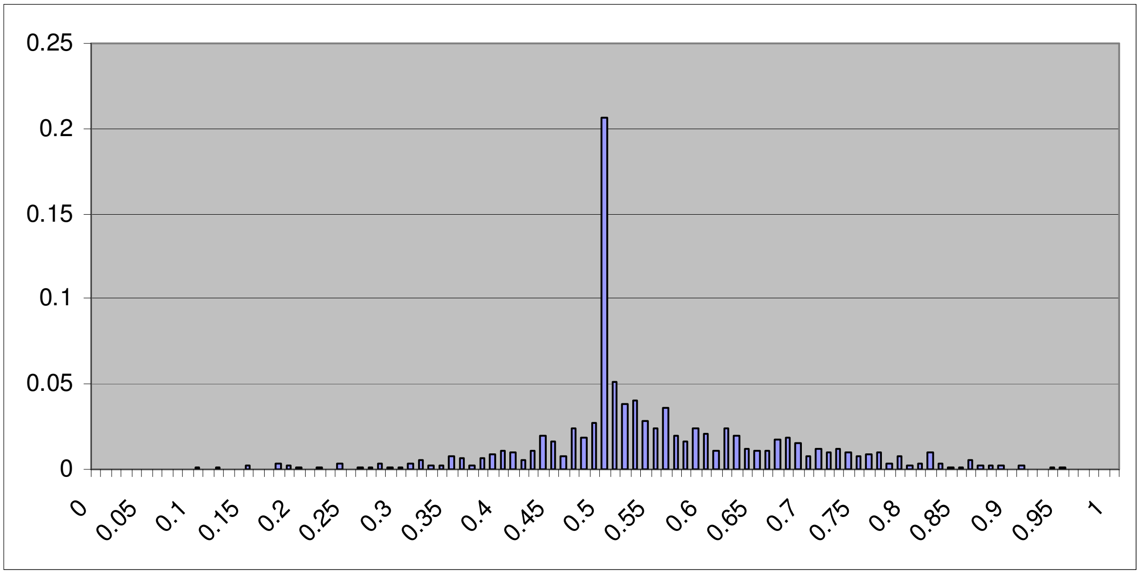
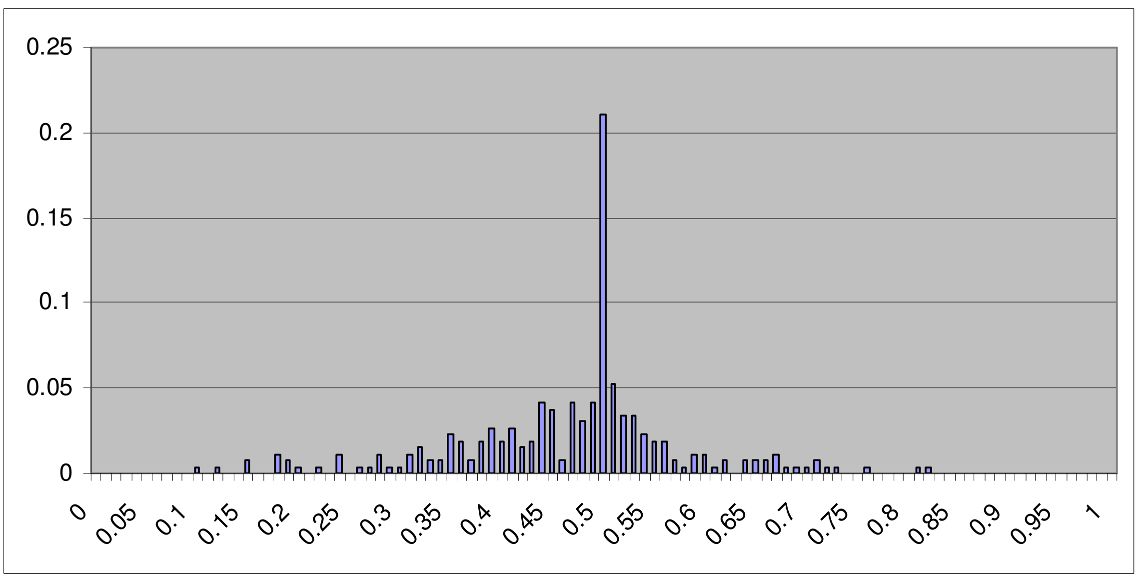
Figure 1



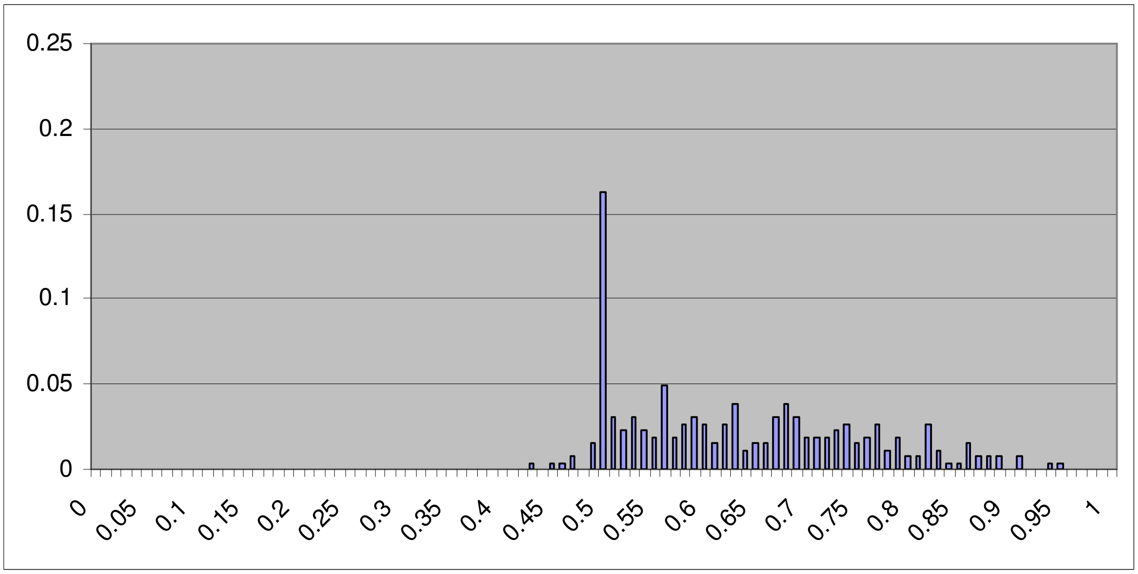
Distribution of Proposer offers over all prices of giving

Figure 2



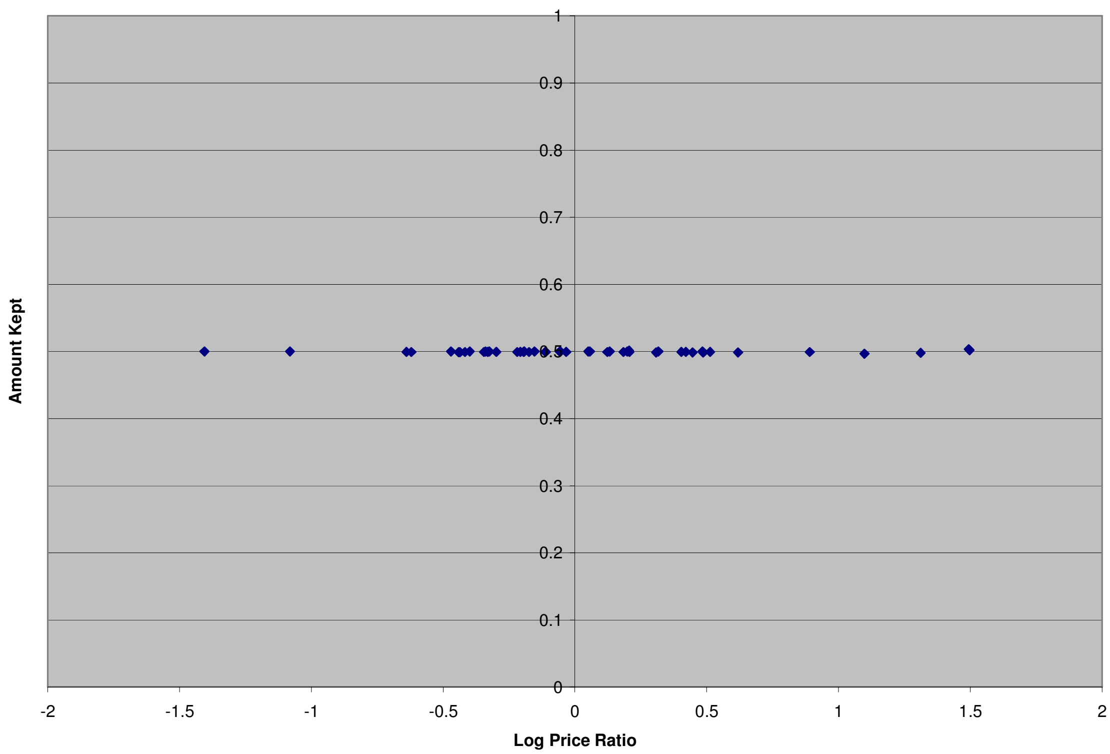
Distribution of Proposer offers where the price of giving was low

Figure 3



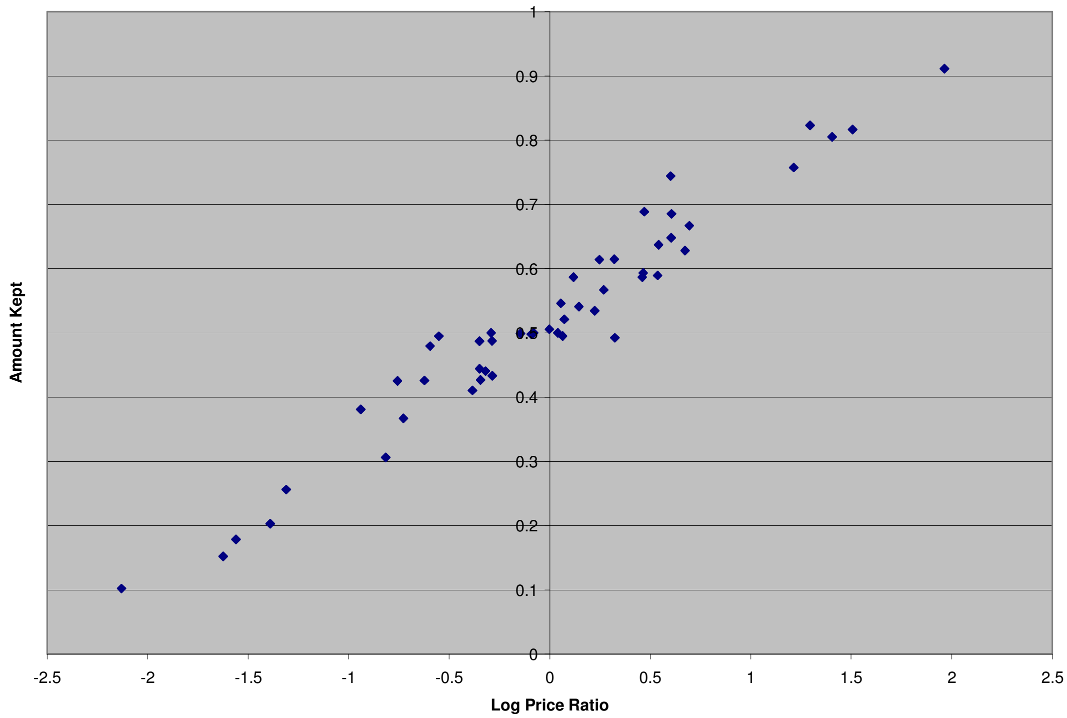
Distribution of Proposer offers where the price of giving was high

Figure 4



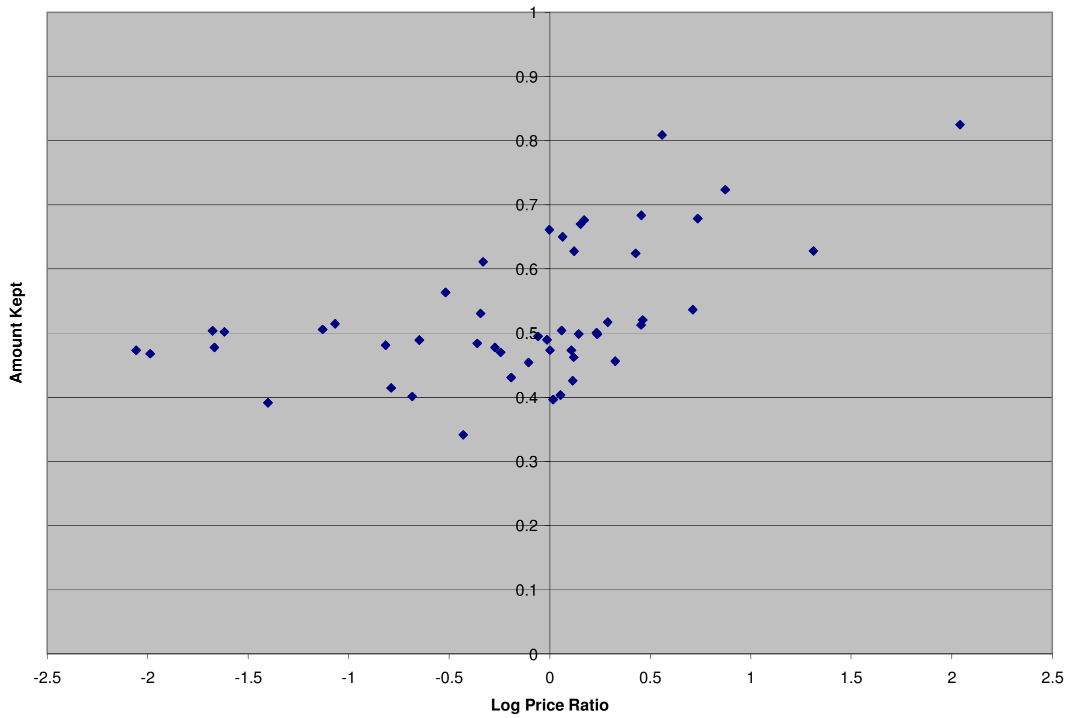
Proposer with difference aversion preferences

Figure 5



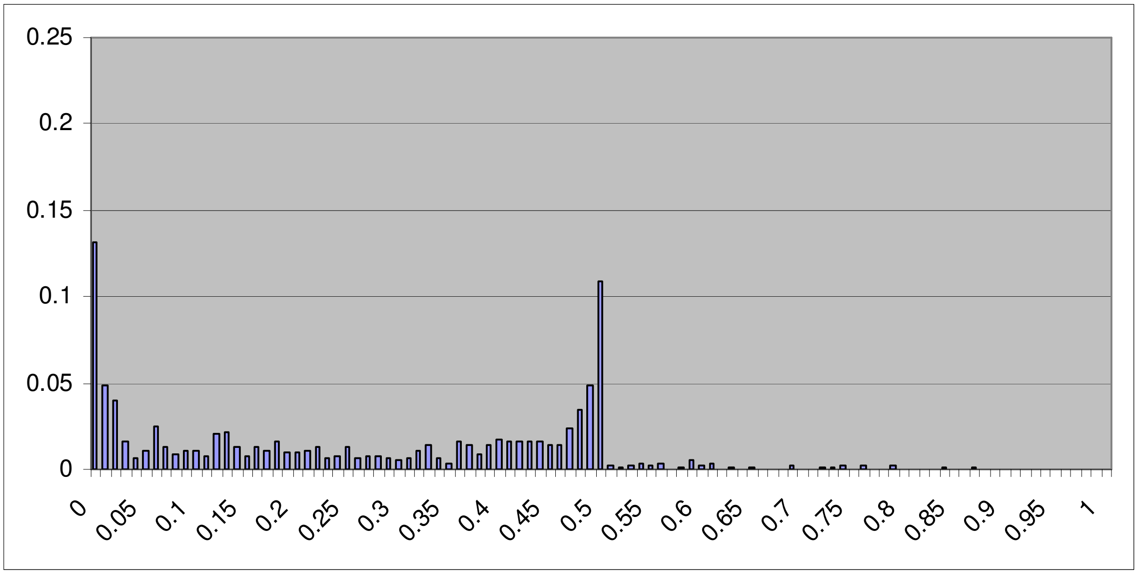
Proposer with social welfare preferences

Figure 6



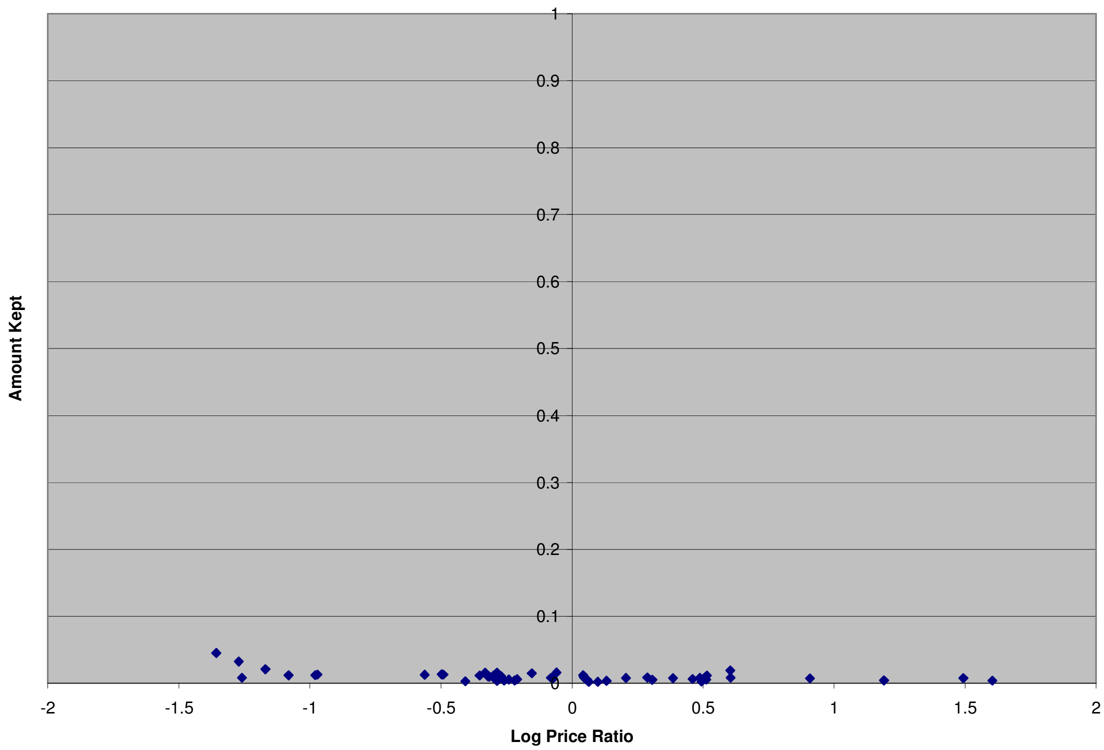
Proposer with mixed social preferences

Figure 7



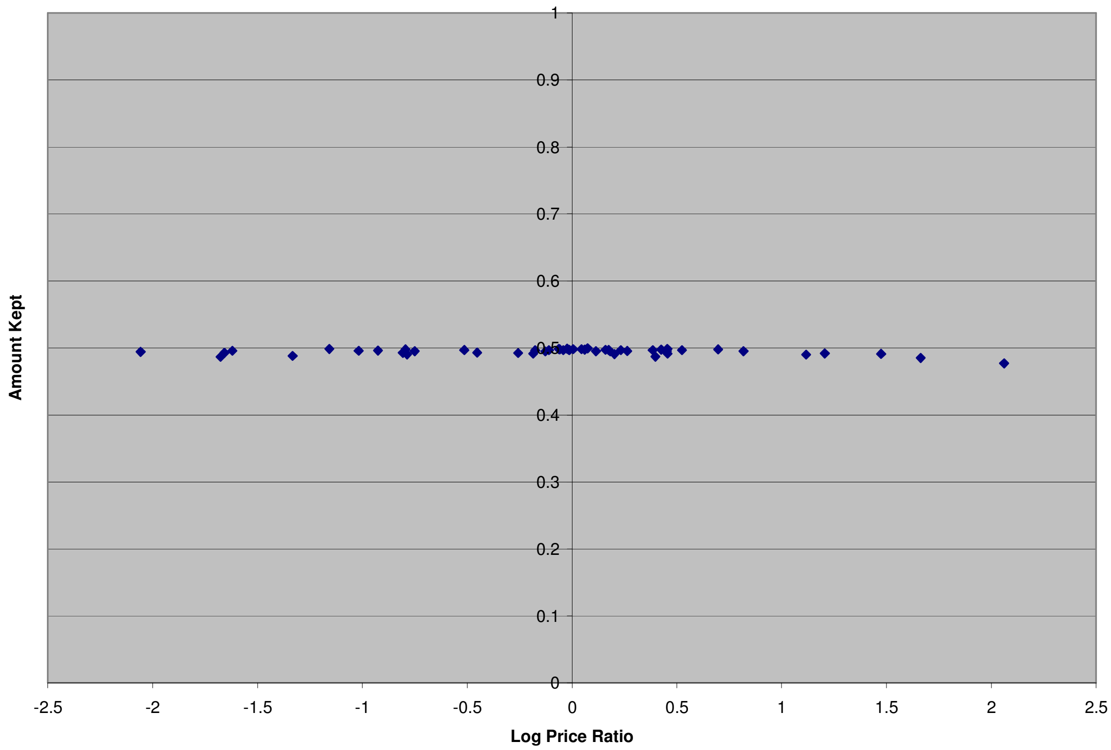
Distribution of Responder reservation prices over all prices of giving

Figure 8



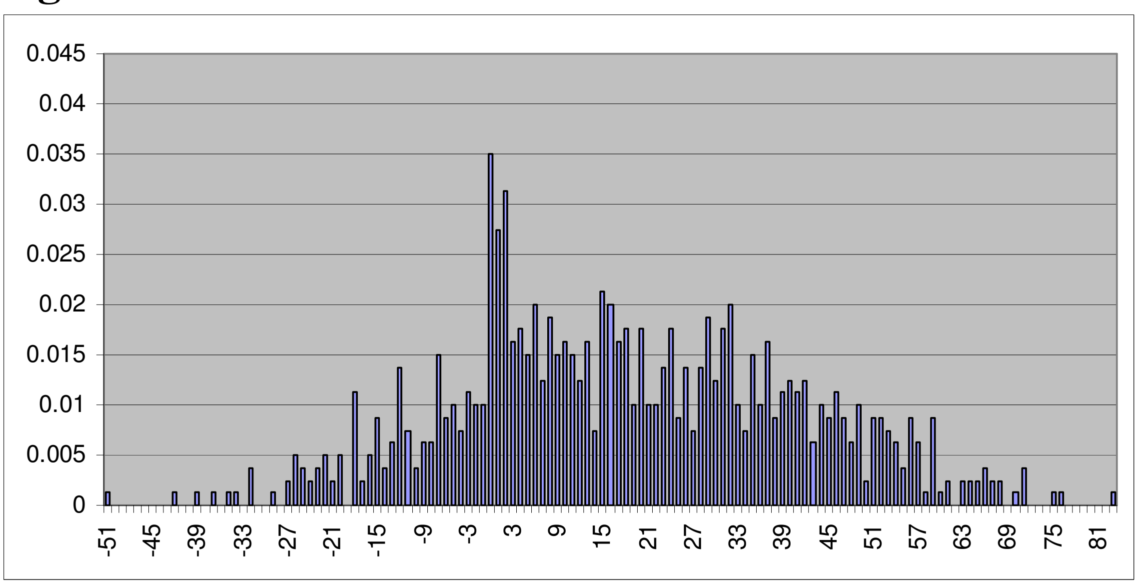
Responder playing according to subgame perfect equilibrium

Figure 9



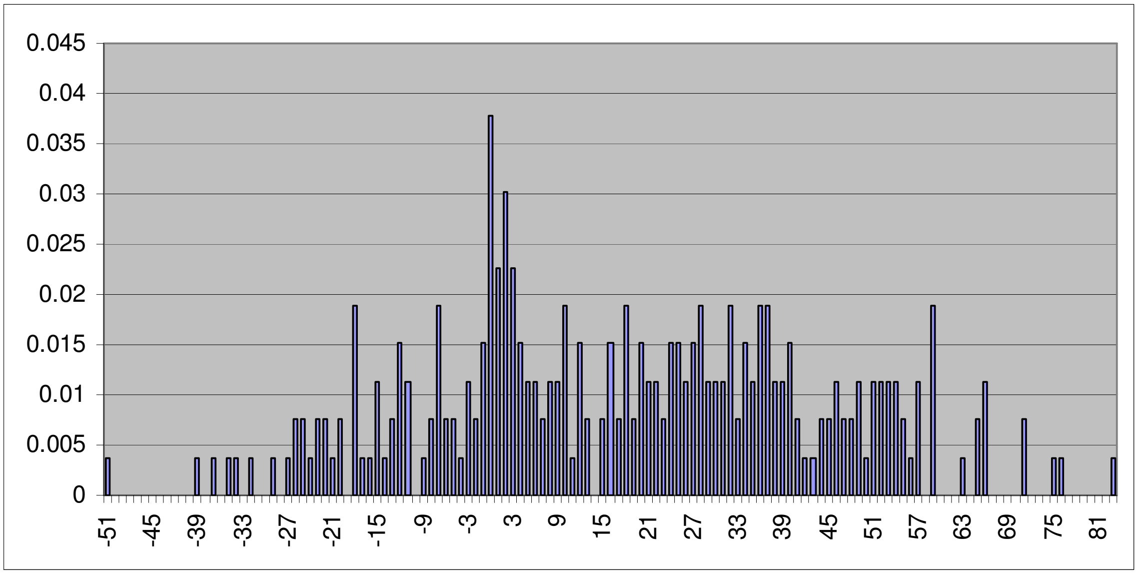
Responder who chooses their reservation price independent of the price of giving

Figure10



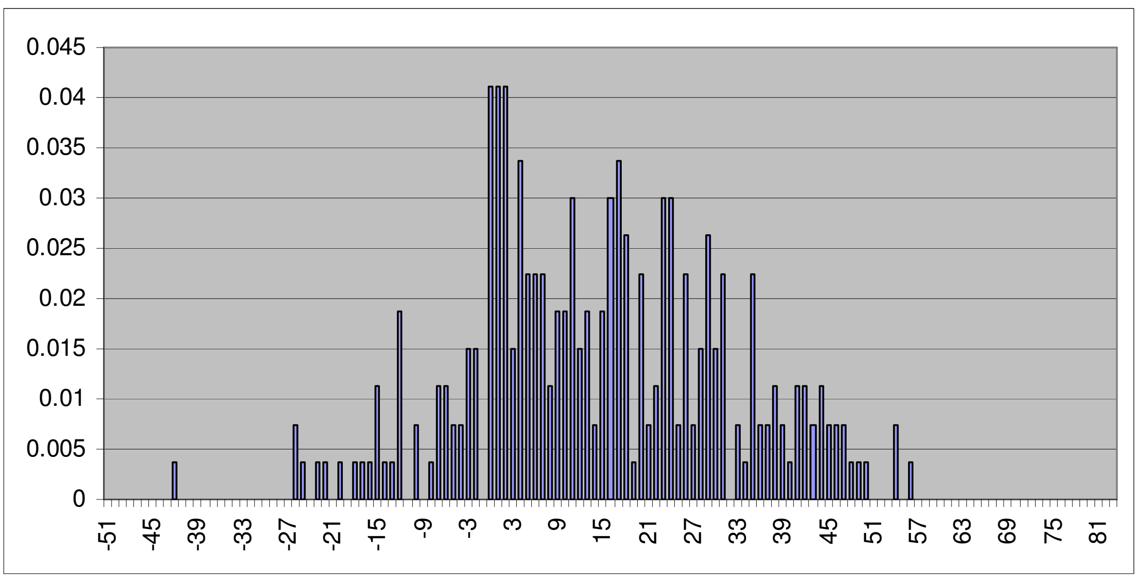
Distribution of the demand spread over all prices of giving

Figure 11



Distribution of demand spread when the price of giving was high

Figure 12



Distribution of demand spread when the price of giving was low

Appendix I: Graphical Interface

Attachment 1