

An Experimental Study of Fair Division *

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Abstract

I consider the problem of allocating a bundle of perfectly divisible goods through two different mechanisms proposed by Crawford (1979, 1980). The “Equal Division Divide and Choose” is a bargaining game where the divider, selected randomly, proposes a division and the chooser can either accept it or reject it. If it is accepted, the proposal is implemented, otherwise each player gets the “equal division”. The other, called “Pareto Efficient Egalitarian Equivalent Allocation”, introduces an extra stage in the game where the role of divider is auctioned off.

I tested these two mechanisms in an experimental setting. The first mechanism gives results that are efficient and envy-free, but not equitable. Experimental data highlights interesting results about fairness when the two players enjoy asymmetric utilities. The second mechanism produces efficient, envy free, and equitable outcomes, even if players are not completely selfish and rational. This happens because of two reasons: the role of divider is not chosen by nature, but it is earned through a fair competition, and dividers pay the auction by transferring part of their payoffs to choosers.

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1 Introduction

The problem of sharing a given amount of resources in a fair way is perhaps the oldest one faced by the homo oeconomicus. The study of fair division goes back to Aristotle's "equal treatment of equals", which can be considered as the first step toward a formal definition of distributive fairness. Brams' (1996, 1999) books are full of anecdotes about divisions of goods: going from the King Solomon's dilemma to the recent Trumps' divorce settlement.

The problem of how resources can be fairly distributed has remained at one of the prominent positions of political, academic, and social life for centuries. In most recent years the literature on fairness has focused on one hand on the properties that a particular fair division procedure generates, and on the other hand on the mechanism with which this division is obtained.

Concerning the former dimension, fair division makes a prominent use of fairness criteria such as envy-freeness, efficiency, and equity. Envy-freeness is a key concept in the literature on fair division: an allocation is envy-free if each agent likes the own share at least as much as the share of any other agent. Ensuring envy-freeness is considered as crucial; however, envy-freeness alone does not suffice as a criterion for finding satisfactory allocations since, as long as agents have different preferences on the resources to be divided, it does not prevent allocations to be inequitable, i.e. to be more advantageous for an agent with respect to the other. Hence envy-freeness has to be paired with some other criterion, such as equity, that has the aim of equalizing the value of bundles allocated to different individuals. Last, it is desirable that the allocation is Pareto efficient, i.e. that it does not exist another allocation that makes all the agents better off.

On the latter dimension, finding a partition is given different meanings: from proving the existence of a division with certain properties to finding methods to compute the desired division. The most common case is the division of the pie, for which many procedures attain divisions responding to some fairness criteria - to quote some: the old "Cut and Choose" method, the more general Banach-Knaster-

Steinhaus “Cut and Trim” procedure for n persons, sliding knives algorithms, multi-step procedures (Brams and Taylor, 1995), and sharing procedures especially designed to be easily understood and used in practice like the “Adjusted Winner ” (Brams and Taylor, 1996).

As Brams (1996) argues, one has to distinguish between “algorithms” and “procedures”: algorithms assume complete and truthful disclosure of preferences to a judge who will then make the partition; procedures look more like a game: they do not require truthful disclosure, but still assume some non-fully-competitive behavior; in game theoretic terms, safety strategies are meant to be played. However, the procedural approach, relying on people “not clever enough” or “not competitive enough”, leaves the implications of purely competitive behavior unexplained.

Crawford (1977) first took up this point: he observed that when the two players know with certainty the preferences of each other and they are motivated by self-interest, the classic “Cut and Choose” procedure generates allocations that are envy-free but not Pareto efficient and not equitable. In fact the divider, by knowing the preference of the chooser, can enforce any feasible allocation that satisfy the property of envy-freeness.

This is where game theory - in particular mechanism design - comes in: if we are to find practical methods whereby people can reach agreements, we need a model of how people reason and behave. How convincing the game-theoretic answer is, will be seen in the next section.

This paper focuses on two methods, both proposed by Crawford (1979, 1980), which have the aim to overcome the unsatisfactory performance of the classic Cut and Choose method in terms of efficiency and equity, in a rational game theoretic setting. These two procedures, the “Equal Division Divide and Choose” (Crawford, 1980) and the “Pareto Efficient Egalitarian Equivalent Allocations” procedure (Crawford, 1979), are expected to generate allocations that satisfies three desirable properties of fairness: Pareto-Efficiency, Envy-freeness, and Equity, which will be defined in section 2.

The purpose of this paper is to show whether the above procedures work well even if subjects are not perfectly rational, through an experiment with real individuals.

This is interesting for two reasons: first, these procedures, although able to satisfy many desirable properties, appear hard to operationalize; second, as happens in most experiments conducted on ultimatum games, subjects often behave inconsistently with respect to backward induction logic. Given that subjects often fail to behave rationally in similar situations, it is useful to investigate whether notions of equity or fairness affects - positively or negatively - the results of procedures whose goal is to generate fair allocations.

Section 2 describes the properties of fairness and the two fair procedures that are going to be investigated - the “Equal Division Divide and Choose” and the “Pareto Efficient Egalitarian Equivalent Allocations” procedure. Section 3 presents the experimental design and the way the experiments were conducted. The expected voting equilibria are also described. Section 4 describes the theoretical predictions. Section 5 presents an analysis of the results of the experiments. Section 6 contains an analysis of the data using the concept of Quantal Response Equilibrium, and Section 7 concludes.

2 Fairness and Fair Procedures

The literature on fair division mainly focuses on devising the game in a way to resolve the conflict without the need for a third neutral party. The goal is to obtain rules able to produce a socially desirable, or “fair” outcome, when all the players act “rationally” in their own selfish interest.

But what does fairness mean? Some of the definitions take as primitives the individuals preferences over possible divisions; another (more recent) strand allows also for claims that the individuals may have over the set of goods to allocate. I adopt the first approach, focusing on division of perfectly divisible goods without money transfers.

As Varian (1974) points out, any definition of fairness formalizes at the end a theme of symmetry in distributive justice. Equity comparisons should allow us to evaluate each agent’s allocation from another agent’s point of view, in other words we

should be able to make interpersonal comparisons of some sort. Considering the case of *pure fair division*, a fair outcome is expected to satisfy three minimal properties. Assume one unit of a finely divisible object to be divided between two individuals, player A and player B , player A takes a subset z of the pie, and B takes the subset $1 - z$. The properties a fair allocation should satisfy are:

Proposition 1 (Envy-freeness) *An allocation is envy-free if every player does not prefer another player's bundle to his own at a given allocation.*

$$U^A(z) \geq U^A(1 - z)$$

$$U^B(1 - z) \geq U^B(z)$$

Proposition 2 (Efficiency) *An allocation is efficient if there doesn't exist another allocation z' such that it is preferred by every player to their own at a given allocation*

$$\nexists z'$$

$$U^A(z') \geq U^A(z)$$

$$U^B(1 - z') \geq U^B(1 - z)$$

I define *equity* as the Pazner and Schmeidler (1978) concept of equity, called “egalitarian equivalence”, which states that each player should be indifferent between getting his share and some reference bundle, identical for all players. The following proposition formalizes this concept.

Proposition 3 (equity) *An allocation is equitable if $\exists \theta$ which makes each player indifferent between receiving a certain bundle of goods z ($1 - z$) and a fraction θ of each good composing the original bundle¹*

$$U^A(z) = U^A(\theta)$$

$$U^B(1 - z) = U^B(\theta)$$

Each of these three property have received increasing attention, to the point that

¹The *Egalitarian equivalence* property requires the existence of a defined and fixed *egalitarian reference bundle* which is indifferent for every agent to the own allocation bundle (Pazner,1978).

each one alone is often referred to as “fairness” criterium. These properties are attractive because Pareto Efficiency and Envy-Freeness impose very little structure on the structure of preferences, in the sense that not even utility functions are required, whereas Equity does not require utility comparisons. However, the definition of fairness assumed here is the one that take the three properties altogether: efficiency coupled with absence of envy and equity appears to be most appealing definition of fairness.

2.1 Equal Division Divide and Choose method (EDDC)

The Equal-division divide and choose method (henceforth EDDC) is intended to represent a fair division device that can be administered by the agents themselves, without requiring an arbitrator.

Define a fair division problem by (S, N, \wp) , where S indicates a bundle of perfectly divisible goods, or the pie to be divided, N the number of players who must agree on how to share S , and \wp the family of partitions $P = \{S_1, S_2, \dots, S_n\}$ into n -subsets in which S can be divided.

The *EDDC* method establishes that one agent is randomly designated to be the “divider”². The game is played sequentially: first, the divider propose a partition $\{S_1, S_2, \dots, S_n\}$, then the $N - 1$ players, other than the divider, are simultaneously asked to choose between the piece offered by the divider $\{S_i\}$ and an equal division piece (henceforth ED)³.

Focusing again on a two-player game, denote S as a fixed bundle of homogeneous and perfectly divisible goods, player A as the recognized divider and player B as the chooser. Assume that the two players have continuous and strongly monotonic utility function, and that they know with certainty the other player’s preferences. For the sake of simplicity, assume that whenever B is indifferent between two bundles, she chooses the one that maximizes A ’s utility. This assumption is innocuous because a

²One agent is designated to be the divider in some “ex-ante equitable” way, for instance by rolling a die. In this the designation of the divider is equitable.

³An Equal Division consists in N perfectly equal shares, each containing $1/N$ of each of the goods contained in the bundle to be divided.

sufficiently small adjustment in the division proposed by A could induce B to choose the desired choice without substantially altering the utility the two players get from the division.

Assume z is the bundle A intends for himself and that \hat{z} is the bundle derived by an equal division of the pie ($\hat{z} = 1/n = 1/2$), which is labelled as “egalitarian bundle”. The divider offers B a choice between the egalitarian bundle and another allocation $1 - z$. Then A ’s optimal strategy is a solution to the following problem:

$$\begin{aligned} & \max_{0 \leq z \leq 1} U^A(z) \\ \text{s.t. } & : U^B(\hat{z}) \leq U^B(1 - z) \end{aligned}$$

A solution always exists because U^B is a continuous function defined on a compact, non-empty set. At any solution, the constraint must be binding:

$$U^B(\hat{z}) = U^B(1 - z)$$

Crawford (1980) proved that allocations generated by a two player-game, when players have convex preferences, are envy-free, Pareto-efficient and Pareto superior or Pareto indifferent to the equal division⁴. But what about equity? The divider has an advantage: he maximizes his utility, obtaining a utility greater than the egalitarian bundle’s one, while the chooser gets the same utility that the egalitarian bundle would give her.

When each player has perfect information about the other’s preference profiles, this ex-post inequity in the payoff can be removed by auctioning off the role of divider, instead of allocating it randomly as discussed in the next session.

⁴In a game with more than 2 players, the allocations are Pareto-efficient and Pareto superior but not necessarily envy-free.

2.2 Procedure for generating Pareto Efficient Egalitarian Equivalent allocation (PEEA)

In order to remove the ex-post asymmetry of the EDDC results, Crawford modified the EDDC model, by auctioning off the role of divider (Crawford, 1979).

According to the Pareto Efficient Egalitarian Equivalent Allocation procedure (henceforth PEEA), each player bids some scalar multiple λ of a numeraire bundle x . The highest bidder wins the privilege of being the divider. The divider will pay the auction, by adding λx to the egalitarian bundle of the choosers⁵, then the new reference bundle he will offer to the other players will be $\hat{z} = (\frac{1}{n} + \lambda x)$, whereas the bundle he intends for himself is $\tilde{z} = [z - (n - 1)\lambda x]$.

The divider therefore pays the chooser for the role of divider. Each player has a well defined reservation price for the role of divider since they know the level of utility they would attain as divider and their utility as chooser. Once a numeraire has been agreed upon, there exists a unique price that makes every agent indifferent between the roles of divider and chooser.

In a two player-game the divider's optimal strategy (assuming that player A wins the auction) is a solution to the following problem:

$$\begin{aligned} & \max_{0 \leq z \leq 1} U^A(\tilde{z}) \\ \text{s.t.} \quad & : U^B(\hat{z}) \leq U^B(1 - \tilde{z}) \end{aligned}$$

where $\tilde{z} = [z - \lambda x]$ and $\hat{z} = (\frac{1}{2} + \lambda x)$

Any solution must satisfy the indifference condition:

$$\begin{aligned} U^B(\hat{z}) &= U^B(1 - \tilde{z}) \\ U^B(\frac{1}{2} + \lambda x) &= U^B(1 - \tilde{z}) \end{aligned}$$

In the auction described above, for any numeraire bundle there exists a unique

⁵This establishes the egalitarian reference bundle such that every agent is indifferent between the reference bundle and her own allocation bundle.

price that makes each agent indifferent between the roles of divider and chooser. Then, the allocation generated gives each agent the same utility that the reference bundle $(1/n) + \lambda x$ would. Therefore:

$$\begin{aligned}
 U^A\left(\frac{1}{2} + \lambda x\right) &= \max_{0 \leq z \leq 1} U^A(\tilde{z}) \\
 U^B\left(\frac{1}{2} + \lambda x\right) &= \max_{0 \leq z \leq 1} U^B(\tilde{z}) \\
 \left(\frac{1}{2} + \lambda x\right) &= \theta_A = \theta_B
 \end{aligned}$$

3 The Experiment and Experimental design

The experimental analysis presented here tests whether the two models discussed previously work in an experiment with real individuals and whether the outcomes of the EDDC and PEEA games are the same as the theory predicts. This analysis investigates the degree with which the outcomes depart from the predicted equilibrium, whether the outcomes of the two types of agents differ, and whether the chooser's rejection behavior is different in the two games.

Since most of the experimental results of ultimatum games show a fairness component in subjects' behavior, it is investigated whether subjects' fairness attitudes allow them to select a fair equilibrium (equivalent to PEEA equilibrium) even in the EDDC treatment. Specifically, if nontrivial offers were due solely to dividers' concerns about fairness, the distributions of offers would be the same in the two treatments. Alternatively, if distributions differ, other factors influence offer distributions. The "fairness hypothesis" is tested by testing that the distributions of offers are the same in the EDDC and in the PEEA treatment.

Two sessions of experiments were conducted with undergraduates at New York University during the Spring 2004. The experiment was conducted in the Center for Experimental Social Science's computer lab⁶.

Each experimental session consisted of twelve rounds played by students who

⁶The experiment was programmed and conducted with the software z-Tree (Fischbacher 1999).

enrolled in the NYU e-recruit subject pool. Subjects had joined the subject pool voluntarily by completing a form on line indicating their interest in participating in experiments. When a student enrolled for participation in the experiment, she was told only that she would participate in a Bargaining Experiment and that “The experiment will last about 1 hour and 30 minutes. Subjects should earn between \$15 and \$25”.

To operationalize the two models, two treatments were conducted (a first corresponding to the EDDC model and a second corresponding to the PEEA one) on 24 subjects in two sessions of experiments, each of them with 12 students. To minimize any possible cross session influences on the outcomes of the experiments, the participants were allowed to participate in only one session.

Every subject was asked to participate to a six-round long EDDC treatment. At the end of the sixth rounds, without any previous announcement, they were asked to participate in a further treatment, composed by six more rounds. The 24 subjects composed 2 groups, each composed by 12 subjects denominated Type A and Type B. Every member of a group was randomly paired with a different member of the other group at every round, such that each pairing in each treatment was unique⁷.

When all subjects had arrived they were assigned to separate cubicles, each furnished with a pc and a desk, such that the subjects could not see anyone except the experimental personnel, nor could they be seen by other subjects.

Subjects were given three tables with the experimental points attached to every potential division they would evaluate and instructions on computer monitors. The instructions included specific interactive examples to clarify the use of the tables. After that, subjects were given an opportunity to ask questions.

At the end of the instructions, each subject was randomly assigned as a Type A or Type B. No subject was informed of the identity of the subjects with whom they were paired.

Every group was given a bundle composed of two goods x and y and every subjects

⁷In this way there was a total of 72 (12 pairs*6 rounds) different bargaining pairs for each treatment.

was endowed with different preferences on the two goods by assigning different individual values to the same objects. Allocation of objects translates into a monetary payoff distribution. The utility functions of the two types were common knowledge:

$$U^A(x, y) = 30x + 90y$$

$$U^B(x, y) = 60x + 20y$$

After the instructions, subjects were asked to play 6 rounds (*EDDC treatment*). Each type played 3 times as divider and 3 times as chooser. The EDDC treatment consisted of a single stage game: the subject who was selected to play as divider offered to the chooser a proposed bundle $(1 - z)$. If the chooser accepted it, she would receive $(1 - z)$ and the divider received z , while if she rejected it, both agents received $\frac{1}{2}$ of every good (the egalitarian bundle).

At the end of the sixth session, they were asked to play 6 more sessions (*PEEA treatment*). The PEEA treatment consisted of a two-stage game: in the first stage every agent bid to win the role of divider, while in the second stage the agents played the same game as EDDC with two differences: first, the divider was the subject who made the highest bid, and second, the egalitarian reference bundle was now $(\frac{1}{2} + \text{the price of the auction})$ for the chooser and $(\frac{1}{2} - \text{the price of the auction})$ for the divider.

The auction stage was a “second price auction”, therefore, the subject who made the highest bid won the role of divider, but he paid the second highest bid, transferring it to the chooser’s reference bundle. In the second stage, the divider would offer to the chooser a proposed bundle. If the chooser accepted the proposed bundle, she would receive $(1 - z)$ and the divider the remaining part of the pie z , while if she rejected it, she would receive the new reference bundle $(\frac{1}{2} + 2\text{nd highest bid})$ of every good, and the divider $(\frac{1}{2} - 2\text{nd highest bid})$ of every good.

The equilibria in the two treatments are shown in Table 1. As theory predicts, in the PEEA treatment there exists a unique price ($\lambda = .25$) that makes each agent indifferent between the roles of divider and chooser. No matter who is the divider, the utility of the two players are the same: the payoffs a player can achieve as the divider are exactly equal to those he would gain as the chooser. The division is Pareto

Table 1: Equilibria.

EDDC	A is the divider	B is the divider
Egalitarian Bundle	$(\frac{1}{2}, \frac{1}{2})$	$(\frac{1}{2}, \frac{1}{2})$
Divider's proposal	$(\frac{2}{3}, 0)$	$(0, \frac{2}{3})$
A's Utility	$U^A(\frac{1}{3}, 1) = 100$	$U^A(0, \frac{2}{3}) = 60$
B's Utility	$U^B(\frac{2}{3}, 0) = 40$	$U^B(1, \frac{1}{3}) = 66.6$
Equivalent Share of the Pie	$[\theta_A = .83; \theta_B = .50]$	$[\theta_A = .50; \theta_B = .83]$
PEEA	A is the divider	B is the divider
Equilibrium bid	$(\lambda^A)^* = .25$	$(\lambda^B)^* = .25$
Chooser's Reference Bundle	$(\frac{3}{4}, \frac{3}{4})$	$(\frac{3}{4}, \frac{3}{4})$
Divider's Reference Bundle	$(\frac{1}{4}, \frac{1}{4})$	$(\frac{1}{4}, \frac{1}{4})$
Divider's proposal	$(1, 0)$	$(0, 1)$
A's Utility	$U^A(0, 1) = 90$	$U^A(0, 1) = 90$
B's Utility	$U^B(1, 0) = 60$	$U^B(1, 0) = 60$
Equivalent Share of the Pie	$\theta_A = \theta_B = .75$	$\theta_A = \theta_B = 0.75$

Notes - The table reports for each treatment (upper and lower panel) and each divider type (columns), the Egalitarian reference bundle, the equilibrium proposals, the equilibrium bid, and the utility of each player.

efficient and equivalent to an equal allocation that gives to each player $3/4$ of the pie.

The differences between the EDDC treatment and the second stage of the PEEA treatment may not only merely change the payoffs matrix of the game, but may also lead to some differences in the behavior of the subjects. The fact that the role of divider is not randomly assigned, but is earned through the auction process, could mean that the divider has a perceived right to a greater portion of the pie in the second stage of the game. In an experiment conducted by Guth and Tietz (1986), when the divider earned the right in a contest, he proposed to the chooser less than in the case when he obtained that right by the nature. On the other hand, they found that choosers accepted the divider's divisions with a greater probability when the divider earned the right in a fair contest than in a random situation. Chooser seem not to be willing to punish dividers for something they earned the right to achieve.

Finally, the fact that dividers pay the auction by transferring part of their egalitarian bundle to the chooser's reference bundle, makes choosers better off and dividers's reference bundle poorer. Choosers are better off because they gain more by accepting the offer than in the random designation procedure, therefore they should be less

willing to reject the divider's division.

4 Expectations and conjectures

My expectations about the experimental results can be described by the following hypotheses.

Hypothesis 1: Divider's offers in the EDDC and the PEEA. Dividers offer to the chooser a payoff greater than the one she would receive by the reference bundle. This extra payoff is greater in the EDDC treatment than in the PEEA one.

According to the theory of games, dividers maximize their own payoff by making choosers indifferent between the proposal and the reference bundle, as choosers accept the proposal unless it gives her a lower utility than the egalitarian bundle.

We expect dividers to make bigger offers than the Nash Equilibrium one, because of two reasons: first, dividers may consider maximizing behavior in the EDDC treatment unjustifiable, since the divider position has been assigned to them in a random way, without any right or effort; second, choosers may consider Nash Equilibrium offers unacceptable, since they lead to unequitable division, opting to reject the offer. This induces the dividers, fearful of potential rejections, to make bigger offers than the Nash Equilibrium.

Turning from the EDDC treatment to the PEEA treatment, the extra payoff offered to the chooser decreases for two reasons: first, choosers consider lower offers in the PEEA (or lower extra profits) more acceptable, because they may think that dividers have the right to make such a proposal. Then, dividers should be less fearful that their proposals will be rejected. Second, dividers pay a price for the role of being divider, therefore they will be more inclined to be selfish in the second stage of the game, offering proposals that are more close to the Nash Equilibrium one⁸.

Hypothesis 2: Equity in the EDDC and the PEEA. The degree of Equity increases turning from the EDDC treatment to the PEEA one.

⁸As Guth and Tietz (1986) discovered, when dividers earn the right in a contest, they propose selfish divisions than when they receive the role randomly.

According to the theory of games, the equilibrium allocation of the PEEA procedure is equitable, since the divider proposes a division which allocated to both the players a same equivalent share of the pie.

We expect that subjects behave consistently with this hypothesis, even if they do not perfectly maximizing their own payoff. This could occur because dividers anticipate that an unfair division will be rejected, therefore giving to the choosers a small extra utility than the egalitarian bundle does. This has a very small effect on dividers' payoffs⁹, but it makes choosers more willing to accept the dividers' proposals.

Hypothesis 3: Fairness hypothesis. Players are selfish, therefore EDDC's and PEEA's allocation differ.

According to the theory of games, the equilibrium allocation of the PEEA procedure are more equitable than the EDDC's allocations. If no difference occur in the allocations, it must be due to fairness considerations by players. If in the EDDC subjects behave in a fair way rather than as predicted by Nash equilibrium, the distributions of offers will be the same in the two treatments and the EDDC's allocations will satisfy the equity properties.

Hypothesis 4: Bidding behavior in PEEA. Players overbid the value of the auction.

According to the theory, the second price auction induces subjects to be more truth telling, leading them to bid their own value of the auction, which is a weakly dominant strategy irrespectively to auction's value distributions.

However, experimental findings show a consistent pattern of overbidding. Kagel, Levin and Harstad (1987) found that the actual bids are on average 11% above the dominant strategy bids. Kagel and Levin (1993) find that about 62% of all bids exceed the bidder's value, while only 8% of all bids were below it. From one hand, overbidding may be explained by the fact that subjects know that they won't pay their actual bid, but only the second highest one. From the other hand, overbidding is sustainable because nevertheless bidders on average earn positive profits.

Morgan, Steiglitz and Reis (2003) analyzed the overbidding behavior from another

⁹For instance, if a type A subject wanted to offer more than the EDDC egalitarian bundle to the chooser, she could select a division which give the chooser 51 experimental points instead of 40 (an increase of 11 experimental points), losing only 4.5 experimental points by her own utility.

point of view: they assume that bidders care not only about their own surplus in the event that they win, but also about the surplus of the winning rival in the event that they lose (the “spite” motive). They showed that, when bidder’s utility function includes a spite motive component, bidders will bid more than their value in second price auctions.

Hypothesis 5: Rejection rates in the EDDC and the PEEA. Choosers reject offers that do not give them an extra payoff with respect to the egalitarian bundle. The rejection rate decreases turning from the EDDC treatment to the PEEA treatment.

According to the theory, choosers accept any offer that give them a greater or equal utility with respect to the reference bundle.

We expect that in the *EDDC* treatment choosers punish dividers if their proposed division lead to large ex-post asymmetries. In fact, the chooser can still choose the “equal division” bundle which would give him a utility irrelevantly smaller than the other bundle, but which will allow him to re-equilibrate the ex-post payoffs. The “punishing behavior” of the chooser is expected to disappear moving to the *PEEA* treatment for two main reasons: first, since the divider won the auction, he earned the right to be the divider and the chooser is less willing to punish him; second, the divider transfers part of his payoffs to the chooser, decreasing the ex-post payoffs asymmetry.

5 Results

This section presents the results of the experiment, that are related to the above described hypothesis.

5.1 *Hypothesis 1: Divider’s offers in the EDDC and the PEEA.*

Hypothesis 1 predicts that dividers are less selfish in EDDC than in PEEA, offering an bigger extra payoff to choosers in the former. Before presenting the results of the

statistical tests, consider Figure 1 and 2 for type A and Figure 3 and 4 for type B.

Figure 1 reports the share of pie the two paired subjects received when the divider was Type A under the EDDC treatment. The data show that in the EDDC treatment no A-type subject maximizes his own payoff and only a total of 24% are close to that prediction (earning a share between .80 and .83). Instead, 30% of the offers display a share difference exactly equal to .75 (45% between .66 and .80). This result is unexpected: a large part of the offers in the EDDC coincide with the forecasted equilibrium of the PEEA treatment.

Turning to the PEEA treatment, 2 shows that 32% of the subjects select a division which leads to a difference exactly equal to the equilibrium one (.75 for both the divider and the chooser), and a total of 88% select divisions in neighborhood of the equilibrium point (between .66 and .80).

Although in the PEEA treatment subjects seem to make equilibrium choices, the divisions do not change substantially moving from the EDDC to the PEEA treatment. Unexpectedly, in the EDDC 30% of the offers match the PEEA equilibrium shares' difference, in which both the divider and the chooser obtain the same share of the pie. Thus, the mean of the distribution does not change, however the variance decreases (in the PEEA treatment only 12% of the divisions are far from the equilibrium).

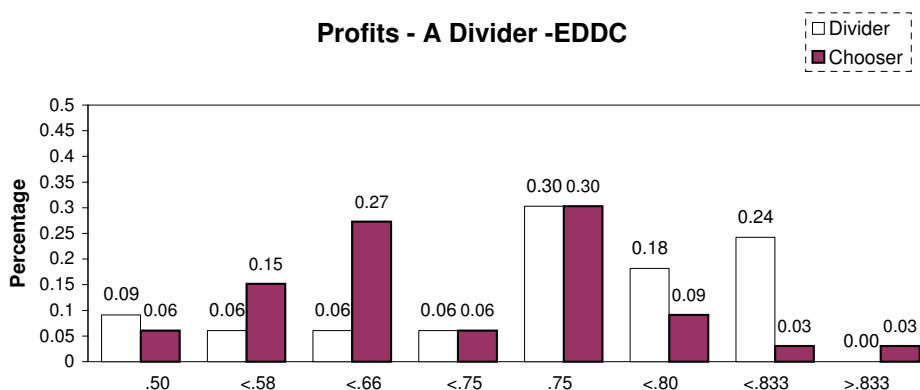


Figure 1: Share of pie for the two players when A is the divider - EDDC treatment. The white bars indicate the divider's profits. The purple bars indicate the chooser's profits.

The divisions when B is the divider are shown in Figure 3. In the EDDC treatment B-type subjects behave as the Nash Equilibrium predicts: they maximize their own share, leaving the chooser with little more than the egalitarian bundle. About 30%

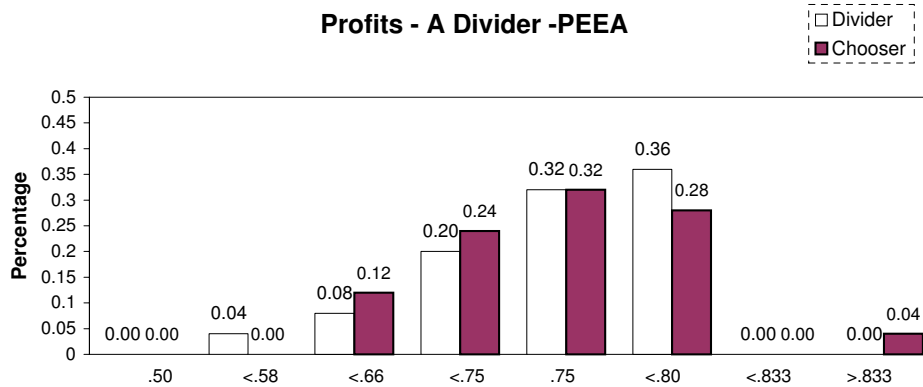


Figure 2: Share of pie for the two players when A is the divider - PEEA treatment. The white bars indicate the divider's profits. The purple bars indicate the chooser's profits.

of the time the B-type divider perfectly maximizes his own payoff, (earning a share equal or greater than .83) and 55% of the divisions are very close to the maximization point (between .80 and .83). Furthermore, 53% of the offers display a share for the chooser very close to the egalitarian bundle (between .50 and .58).

Figure 4 reports the results under the PEEA procedure. Although only 12% of the proposals are exactly at the equilibrium (with a divider's and chooser's equivalent share equal to .75), notice that a total of 65% are close to it (between .66 and .80 for the divider share). The PEEA treatment does not show a clear convergence as in the EDDC, but a bias toward a small positive difference between the divider's and chooser's shares of the pie.

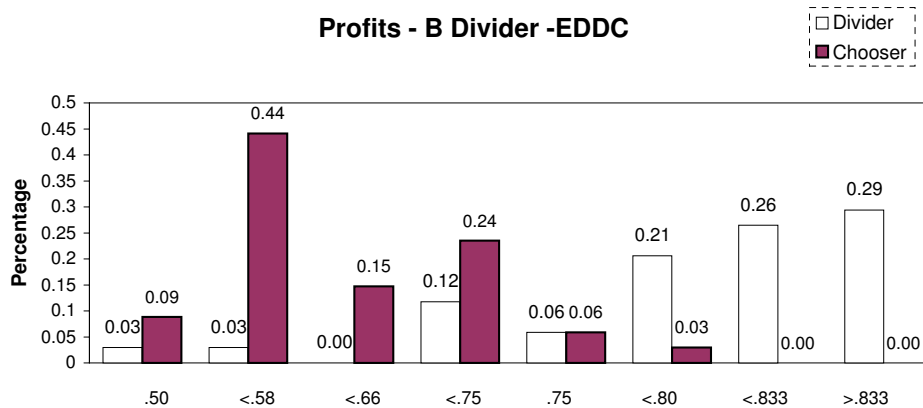


Figure 3: Share of pie for the two players when B is the divider - EDDC treatment. The white bars indicate the divider's profits. The purple bars indicate the chooser's profits.

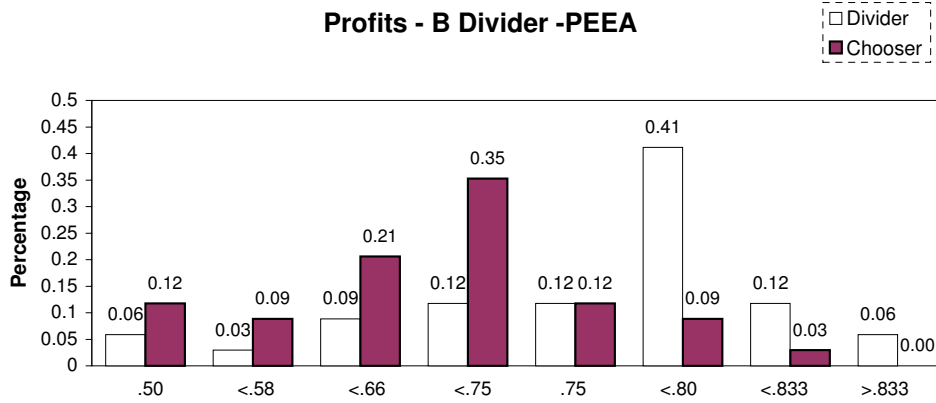


Figure 4: Share of pie for the two players when B is the divider - PEEA treatment. The white bars indicate the divider’s profits. The purple bars indicate the chooser’s profits.

I test the null hypothesis that the observed divider’s and chooser’s share for EDDC and PEEA treatments come from populations with the same median using a Wilcoxon non parametric rank sum test. For type A the equality of the median divider’s share cannot be rejected (P-value=0.415), while the equality of median chooser’s share is rejected at a 5% significance level (P-value=0.017). For type B both the equality of median divider’s share and median choosers’ share is rejected at a 1% significance level (P-value=0.008 and $P=1.009e-7$, accordingly).

In addition, I also used a Kolmogorov-Smirnov test to examine whether the distribution of the observed proposed payoffs was the same across the two treatments. Consistent with the results of the Wilcoxon test, for type A’s data the equality of distributions of divider’s share cannot be rejected (P-value= 0.327), while the equality of distributions of chooser’s share is rejected (P-value= 0.017). For type B data the equality of divider’s share distributions is rejected at the 1% significance level (P-value= 0.010), and it is also rejected against the alternative hypothesis that the support of the distribution function is greater in the PEEA treatment than in the EDDC one (P-value= 0.005). Similar results are obtained testing the equality of the chooser’s share distribution. Both the descriptive and the statistical analysis suggest that Type A behavior is slightly different from the expectations.

Table 4 and Table 5 give the dynamics of the divisions for type A and type B players respectively. Consistent with the descriptive and the statistical analysis, the

average chooser's and divider's payoff of both type A and type B do not change significantly from EDDC treatment to PEEA. Furthermore, there is no apparent learning as the number of rounds increase in the EDDC treatment (on the contrary note that the median offers approach the PEEA equilibria as rounds increase), while it appears to be learning under PEEA treatment (both choosers' and dividers' payoffs approach the target equilibrium).

5.2 Hypothesis 2: Equity in the EDDC and the PEEA.

According to Hypothesis 2, the difference between the equivalent share of the pie that the divider and the chooser receive (θ) decreases turning from the EDDC to the PEEA procedure. Figure 5 and Figure 6 display the difference between the share of the pie that the two paired subjects receive when the divider is type A and type B, respectively.

Figure 5 shows that in EDDC treatment only 15% behave as the equilibrium predicts, and only a total of 24% are close to it (with a share difference between .21 and .30). Note that 36% of the offers display a share difference exactly equal to 0 (45% between -.10 and .9). This results is consistent with the findings in the section 5.1: a large part of the offers in the EDDC coincides with the forecasted equilibrium in the PEEA treatment. Turning to PEEA, 32% of the subjects select a division which lead to a difference exactly equal to the equilibrium one (0), and a total of 68% select divisions close to the equilibrium (between -.10 and .9).

It is not clear that the shares' differences change substantially moving from the EDDC to the PEEA treatment. Unexpectedly, in the EDDC, 36% of the offers match the PEEA equilibrium shares' difference, in which both the divider and the chooser obtain the same share of the pie, suggesting that the mean of the distribution does not change, even if the variance decreases (in the PEEA treatment there are no offers that display a difference greater than .20 between the divider and the chooser).

Figure 6 reports the results when B is the divider. The figure shows that in EDDC treatment 35% of the proposals are at the equilibrium (with a shares' difference equal to .30), and that a total of 59% are close to it (between .20 and .30 points). The PEEA

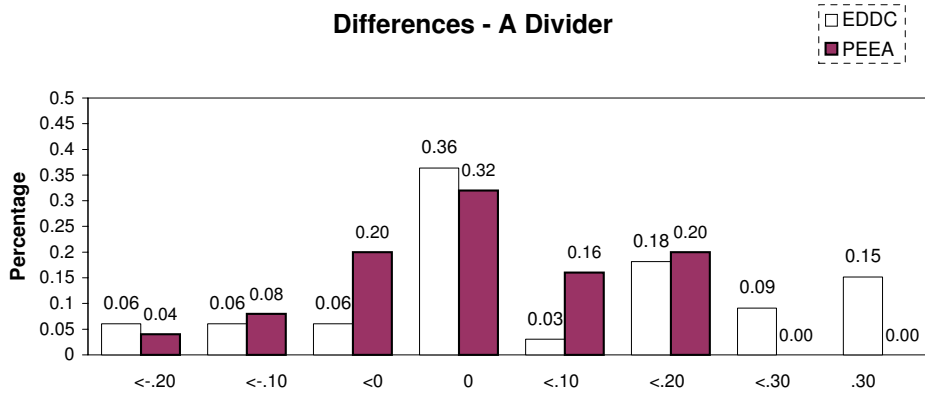


Figure 5: Differences between the Divider’s and Chooser’s share of pie when A is the divider. The white bars indicate the share differences in the EDDC treatment, while the purple bars indicate the share differences in the PEEA treatment.

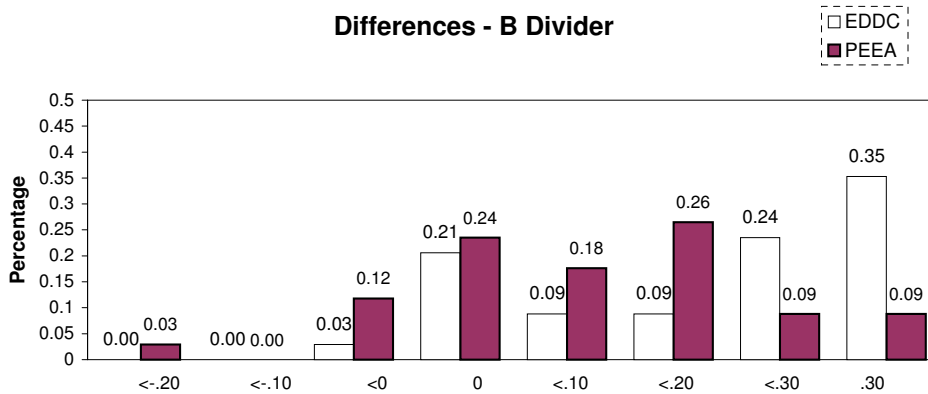


Figure 6: Differences between the Divider’s and Chooser’s share of pie when B is the divider. The white bars indicate the share differences in the EDDC treatment, while the purple bars indicate the share differences in the PEEA treatment.

treatment does not show a clear convergence as in the EDDC but a bias toward a small positive difference: 24% of the subjects select a division which leads to a shares’ difference exactly equal to the equilibrium one (0) and a total of 54% select divisions around the equilibrium (between -.10 and .9), but the mode is between .10 and .19 (27% of the offers). The mean of the share difference change substantially from the EDDC to the PEEA treatment, whereas the distribution does not change as much.

A Wilcoxon non parametric rank sum test yields results similar with the previous section: for type A, the equality of medians cannot be rejected at a 10% significance level (P-value=0.111), while for type B the equality of medians is rejected at a 1% significance level (P-value= 0.004).

A Kolmogorov-Smirnov test confirms the above tests: for type A, the equality of distributions for EDDC and PEEA cannot be rejected (P-value= 0.277). The equality of distributions against the alternative hypothesis that the support of the distribution function is greater for the PEEA treatment than for the EDDC one cannot be rejected as well (P-value= 0.139). For type B data, the equality of distributions for EDDC and PEEA is rejected at 1% significance level (P-value= 0.005), and the equality of distributions against the alternative hypothesis that the support of the distribution function is greater for the PEEA treatment than for the EDDC one is rejected at 1% significance level (P-value= 0.003), as well.

5.3 Hypothesis 3: Fairness hypothesis.

Type A subjects select a fair equilibrium - equivalent to the PEEA equilibrium - in the EDDC model. In the analysis above the hypothesis that type A's offers' distribution does change, moving from EDDC treatment to PEEA one, is rejected. This could mean that A dividers are concerned about fairness issues. They do not only want choosers to have a greater payoff, and thus they decrease their own, preferring to share the pie in a more equitable way. Type A seems to propose almost the same divisions regardless of the treatment. This suggests that Type A is fair, without maximizing her own payoff. There is no need of the PEEA procedure in order to produce equitable divisions.

5.4 Hypothesis 4: Bidding behavior in PEEA.

Table 2 shows the bidding behavior in the auction stage. Both type A and type B are far below the equilibrium bid 0.25. As opposed to the finding of other experimental studies, where subjects overbid the true value of the auction, subjects here deviate to lower bids.

It may be investigated whether subjects gain from winning the auction. In figures 7 and 8, the final payoffs that subjects gain when they won the auction (as divider) and when they lost are compared.

Table 2: Bids.

Rounds	Type A		Type B	
	Mean	Median	Mean	Median
1	0.19	0.18	0.21	0.23
2	0.19	0.20	0.18	0.18
3	0.18	0.15	0.19	0.18
4	0.17	0.15	0.13	0.10
5	0.17	0.18	0.16	0.15
6	0.17	0.18	0.17	0.18

Notes - The table reports for each round (rows) and each type (columns), the mean and the median bid. The equilibrium bid is 0.25 for both the types.

For Type A subjects winning the auction does not result in greater experimental points: in almost every round they ended up with a higher payoff when they were choosers than when they were dividers. For Type B subjects the comparison does not yield a clear result. Nevertheless, we can conclude that winning the auction is not always preferable to losing it.

This unexpected result can have two explanations: first, subjects overvalue the divider-role or they are not able to exploit the divider advantage; second, choosers reject the divider's proposal even when it gives them a greater payoff than the egalitarian bundle.

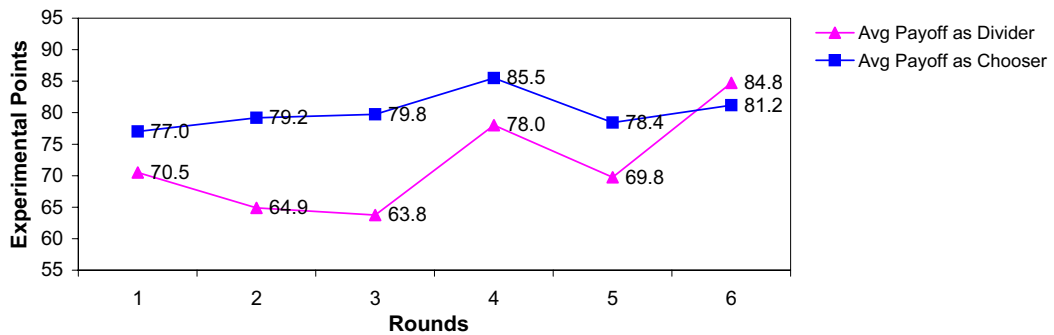


Figure 7: Type A's Profits in PEEA treatment: the pink line identifies the average payoffs when type A subjects wins the auction (assuming the role of divider), while the blue line identifies the average payoffs when type A subjects lose the auction (being the chooser).

The first explanation may be interpreted as “winner curse“. The winner's curse is a phenomenon that occurs in common value auctions with incomplete information.



Figure 8: Type B's Profits in PEEA treatment: the pink line identifies the average payoffs when type B subjects wins the auction (assuming the role of divider), while the blue line identifies the average payoffs when type B subjects lose the auction (being the chooser).

In the game investigated here, the auction is common value (by winning the auction both the players earn extra utility by being the proposer) but they have no complete information about the value of the auction since they do not know what the other type will choose in the second stage of the game. The auctioned good has a similar value for all bidders, but players are uncertain of this value when they bid. Each player independently estimates the value of the good before bidding. The winner of an auction is the bidder who submits the highest bid, which will probably be the bidder whose estimate was largest. Assuming that on average the bidders are estimating accurately, then the agent whose bid is highest has almost certainly overestimated the good's value. Thus, a bidder who wins after bidding what they thought the good was worth has almost certainly overpaid.

According to the second explanation, subjects are rational in estimating the right value of the divider's role, but suffer losses since choosers do not behave rationally, rejecting the proposal even when it gives them a higher payoff than the egalitarian bundle. As Forsythe et al.(1994) points out, after observing the chooser's acceptance rate, a divider may find it optimal to offer to the chooser a significantly higher payoff in order to induce him to accept the division. In this sense, dividers are acting in a manner consistent with expected payoff maximization. However the same cannot be said for the choosers who continue to reject proposals that are non-trivially bigger than the egalitarian bundle.

The chooser's behavior may be also interpreted as "spite" of the losing bidder. If bidder care about the payoffs of the opponent, may be more willing to reject the offers rather than overbidding.

In order to understand if one or both of the potential explanations apply to the experimental results, the final payoffs of only the accepted divisions are compared. If the payoffs when the subject is divider are higher than the payoffs when he is chooser, it may be concluded that the rejection behavior of the choosers leads the bids to diverge from the equilibrium one. Instead, if nothing changes, the winner curse is the main factor that leads to the divergence from the equilibrium bid.

Comparing the payoffs of the accepted divisions only, the results do not change dramatically. Nevertheless the rejection attitude of type B subjects seems to play a non negligible role in type A's bidding and proposing behavior, who do not propose divisions that lead to a substantial difference between the divider's and the chooser's payoffs because of the fear of potential rejections. Moving to B-type's behavior however, it is still difficult to determine a leading pattern in the divider's payoffs.

Although the rejection rate has a significant impact on the expected utility that type A can obtain by winning the auction, the winner's curse explanation cannot be excluded. None of the two possible motivations may be considered as the main cause that leads dividers to be paid less than expected.

5.5 Hypothesis 5: Rejection rates in the EDDC and the PEEA.

Hypothesis 5 forecasts that the probability of a proposal being rejected should be lower in the PEEA treatment than in the EDDC one. In the PEEA treatment, choosers should be more willing to accept dividers' proposals because dividers give them on average a greater payoff and because they feel that even unequitable proposals are justified by the fact that dividers earned the right to gain more than them.

In order to compare rejections in the two treatments, I do not consider the absolute payoffs of choosers because the set of offers and the reference bundles are different in

the two treatments. Instead, I consider the extra payoff, above the egalitarian bundle, that dividers propose to choosers.

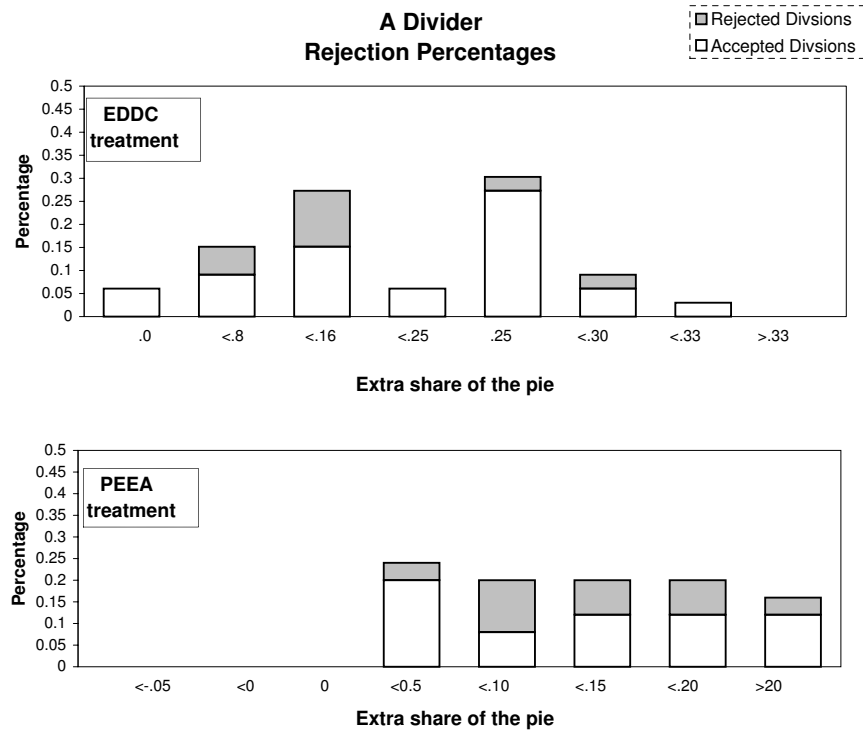


Figure 9: Rejection rate for type A's proposal in the EDDC treatment (upper panel) and in the PEEA treatment (lower panel).

Figure 9 shows the rejections when Type A is the divider. The top panel shows that in the EDDC treatment type B subjects reject a considerable proportion of the offers when they give them a small extra payoff. Subjects of type A appear to propose more “equitable” because they would face a higher probability of rejection otherwise.

Turning to the bottom panel, which shows the rejection rate in the PEEA treatment, the interpretation of the results is not as clear. In this treatment type B subjects are asked to accept or reject proposals that would be fair even if the divider did not give the chooser an extra payoff. Nevertheless, type B choosers still reject a high proportion of the offers.

Figure 10 shows the rejections when Type B is the divider. The data shows clearly that in the EDDC treatment Type A choosers reject a very low proportion of offers, even when the extra payoff is small. This behavior corroborates the hypothesis that type A subjects are seriously concerned about fairness both when they are in the

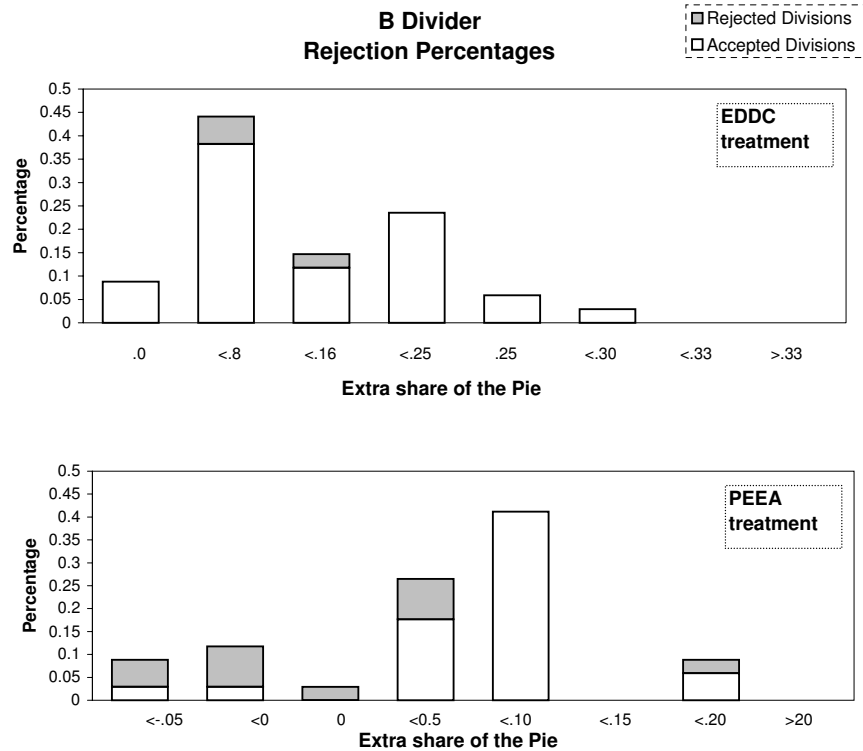


Figure 10: Rejection rate for type B's proposal in the EDDC treatment (upper panel) and in the PEEA treatment (lower panel).

position to propose a division and when they decide to accept or reject a division from the pairing subject.

Turning to the PEEA treatment almost all of the rejections are concentrated on offers which give the chooser less than the reference bundle. Elsewhere, type A subjects reject less offers, supporting my hypothesis.

Results are different for type A and type B subjects. Type A subjects behave according to my hypothesis (for all the admissible proposals), while type B ones appear to desire to punish their partners for having an advantaged position.

6 Quantal Response Equilibrium analysis

Some recent research in experimental economics has made use of McKelvey and Palfrey's (1995) Quantal Response Equilibrium (QRE) model to reconcile deviations from Nash equilibrium predictions.

In the QRE every strategy is played with positive probability. In an extensive-form game, where D is the Divider and C is the Chooser, the Divider's strategies can be identified by the proposals p_i and the Chooser strategies are denoted by $A|p_i$ if he accepts the proposal and $R|p_i$ if he rejects it. The expected payoffs are given by:

$$U^D(p_i) = (1 - p_i)Pr(A|p_i);$$

$$U^C(A, p_i) = p_i; \quad U^C(R, p_i) = 0;$$

In a sequential QRE (called AQRE: Agent Quantal Response Equilibrium), at any information set, the difference in the expected payoffs between accepting or rejecting the offer is the size of the offer. Therefore, for each agent of the Chooser type, it is better to accept a positive offer and the limiting QRE, as the noise disappears, is a sequential equilibrium.

In the case of discrete strategy spaces, the set of offers $p = \{p_0, p_1, \dots, p_k\} \subset [0; 1]$, where $k + 1$ is the number of possible proposals, can be reduced to $\tilde{p} = \{\tilde{p}_0, \tilde{p}_1, \dots, \tilde{p}_m\}$ where \tilde{p} is a partition of p . The set of proposals are here partitioned in five subsets ($m+1=5$) where \tilde{p}_0 is the most rational subset of proposals (Nash Equilibrium's neighborhood) and \tilde{p}_4 is the most altruistic subset of proposals (the chooser's equivalent share of the pie is bigger than the divider's one). Notice that \tilde{p}_3 is a singleton containing the "equitable proposal".

Figure 11 show the QRE for the Chooser. The blue and red lines identify Type A and Type B choosers, respectively. Note that the QRE for each subset of proposals converges to 1 (the Nash Equilibrium) as λ , the learning, increases. The QRE concept captures the proposal size effect: as the proposals become more fair, the degree of convergence increases. Also note that the red line lies always under the blue line, which implies that Type B's probability of accepting a proposal converges to the Nash Equilibrium more slowly than Type A's. In other words, the probability that a proposal is accepted is greater when the Chooser is Type A than Type B. This is consistent with the "optimization premium" theory: since players are more likely to play a best reply strategy when the difference between the utility attached to the best reply strategy and the inferior strategy is big, type B chooser are less likely to accept

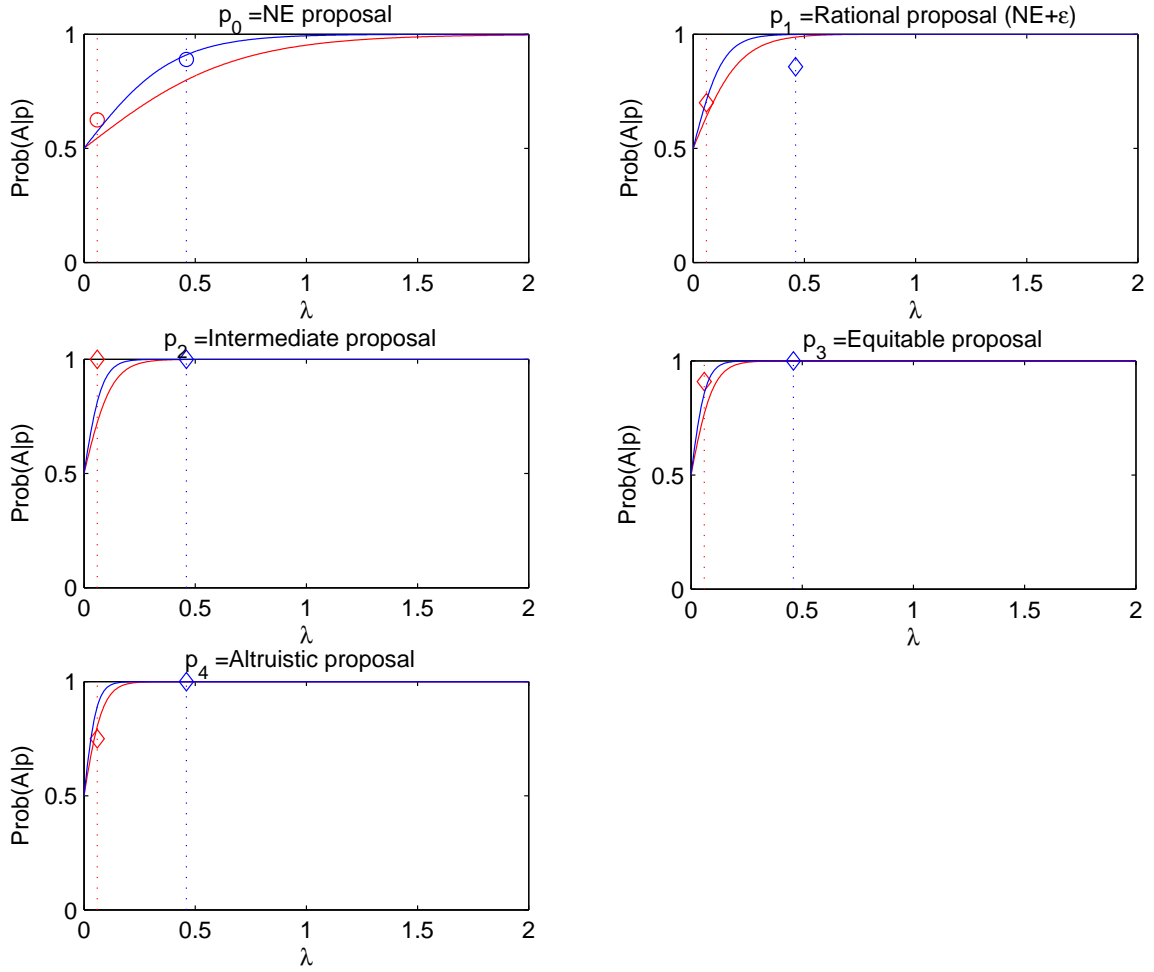


Figure 11: QRE of the Chooser's probability to accept the proposals. The blue lines identify Type A's probabilities, while the red lines identify Type B's probabilities.

the offers than type A.

As opposed to the Nash Equilibrium concept, QRE is function of the size of the offer, and it is therefore able to predict a the difference in rejection behavior between type A and type B, highlighted in section 5.5.

Figure 12 shows the QRE for the Divider's proposal subsets \tilde{p}_0 (NE proposal) and \tilde{p}_3 (Equitable proposals). The blue and red lines identify Type A and Type B dividers, respectively. The plot on the left, for the NE strategy, shows that the QRE is a negative function of λ when λ is very small (close to zero), and after a cutoff point level of λ it becomes positive. This is explained easily by the logistic quantal response function for the divider:

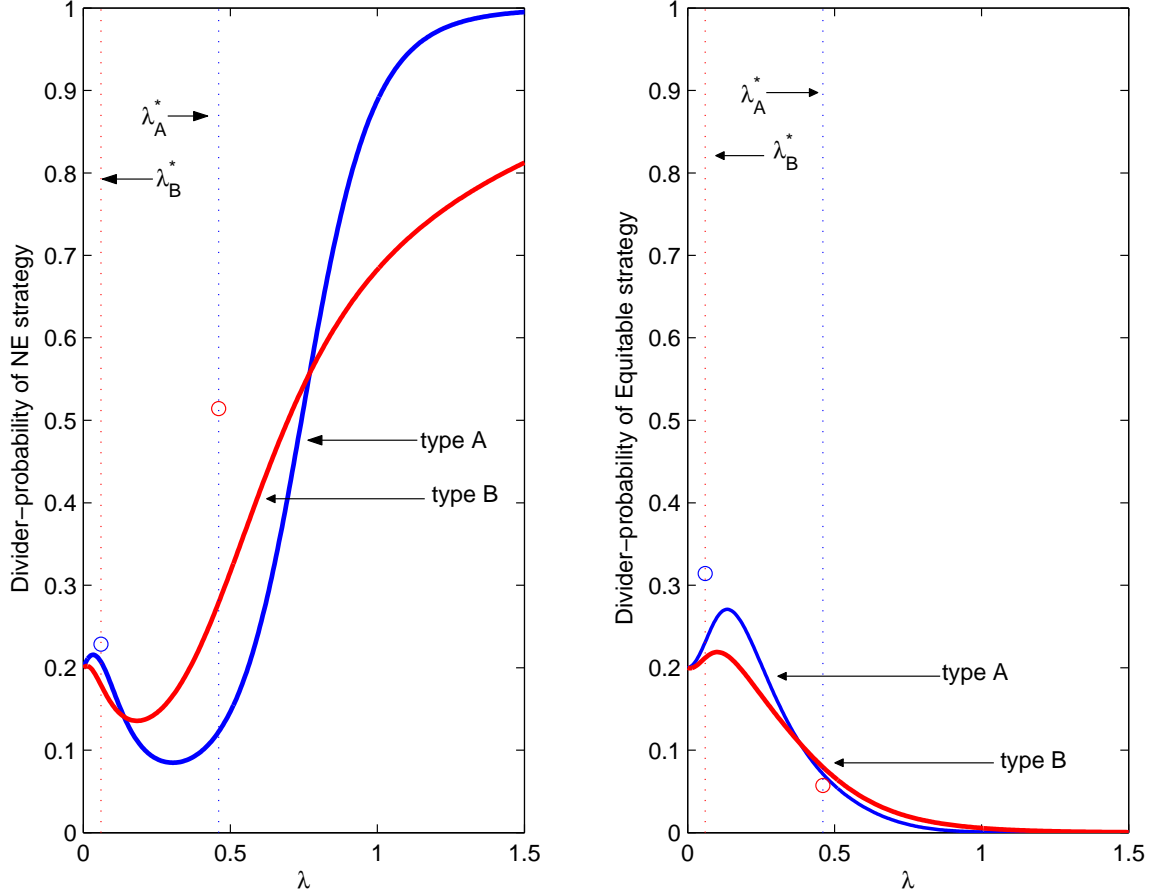


Figure 12: QRE of the Divider’s probability to accept the proposals. The blue lines identify Type A’s probabilities, while the red lines identify Type B’s probabilities.

$$\pi_{NE} = \pi_0 = \frac{e^{U^D(p_0)*\lambda}}{\sum_{i=1}^5 e^{U^D(p_i)*\lambda}}$$

where $U^D(p_0) = (1 - p_0)Pr(A|p_0)$.

From Figure 11, for low level of λ , the probability of accepting the NE proposal is low, compared with the probability of having the proposal accepted for proposals belonging to other subset. This results in $U^D(p_0)$ being lower than $U^D(p_i)$ with $p_i \neq p_0$.

The left plot in Figure 12 also shows that the marginal effect of λ is bigger for Type A divider’s proposals. This may occur because type B’s acceptance probability is more sensitive to λ . For small values of λ , type A chooses the NE equilibrium strategy rarely, while choosing the equitable strategy with a probability close to 0.3.

Table 3: QRE estimation of EDDC treatment.

MLE	λ	LogL value
Type A Divider	0.06	-74.18
Type B Divider	0.46	-66.68

Notes - The table reports for each divider type (rows), the estimated lambda and the LogLikelihood value.

Type B's behavior is instead less noisy, with a greater probability of choosing the Nash Equilibrium strategy and a lower probability of choosing the equitable one. Again, being function of the size of the offer, QRE is able to predict the difference between type A and type B found in section 5.1.

Table 3 reports the estimated λ for the two types of players. The estimated λ for type A is low, which implies that type A's behavior is extremely noisy, while type B's behavior is instead closer to the Nash predictions.

Low estimated values of λ are consistent with the experimental literature on ultimatum bargaining games. In the Nash equilibrium, all positive proposals must be accepted, but this prediction is chronically violated in experiments. Most proposals are concentrated between 30% and 50%, and smaller positive proposals were often rejected. The limiting AQRE gives a unique selection of a trembling-hand perfect equilibrium with the minimum positive proposal and, since it is always better for the choosers to accept a positive offer, the AQRE approaches the sequential Nash equilibrium with a high rate of convergence. This leads to an estimate of λ very close to zero.

7 Conclusions

This paper provides empirical support that the procedure for generating Pareto Efficient Egalitarian Equivalent allocation (PEEA) designed by Crawford (1979) results in efficient and envy free allocations as well as equitable ones. Moreover, it provides additional insights about fairness preferences of individuals who face divisions problems and ultimatum games.

In a common knowledge environment the PEEA procedure induces even the most selfish player to divide a pie in an equitable way. Unexpectedly, data shows that if a player receives a greater utility from the whole pie than the player he is paired with, then he will split the pie in an equitable way even without such a procedure. The fact that the distributions of proposal for this type of subjects are identical in EDDC and PEEA treatments is evidence for this surprising result.

The data from the experiment are consistent with the results of the previous experiments on ultimatum games: subjects deviates from the Nash Equilibrium prediction. In this experiment the magnitude of the deviation is smaller than in classical ultimatum games because the payoff for the chooser in case of rejection is not zero but half of the pie.

A Quantal Response analysis shows that the QRE concept fits the experimental data better than the Nash equilibrium. In particular, QRE is able to capture the proposal size effect: as the divider's proposals become larger, the chooser's probability of accepting the offer increases. QRE is also sensitive to the asymmetry between type A and type B: the probability of accepting a proposal converges to the Nash Equilibrium more slowly for the type who receives a lower utility from the whole pie. The chooser's probability of accepting the divider's offers affect in turn the divider's probability to propose a division. Since for sufficiently low values of λ the probability of having a proposal accepted is higher for an offer larger than the Nash Equilibrium one, the divider's probability of proposing a division will be higher for the former than for the latter. The asymmetric chooser's probability of accepting an offer explains in turn the asymmetric divider's probabilities of proposing a division.

Table 4: Type A-division dynamics.

Rounds	Chooser's Payoff				Divider's Payoff			
	NE	Mean	St. Dev.	Median	NE	Mean	St. Dev.	Median
EDDC Treatment								
1	40	52.75	8.61	53.50	100	87.63	11.87	90.00
2	40	54.33	8.14	51.00	100	88.83	11.69	94.50
3	40	53.50	8.61	57.00	100	85.25	13.43	90.00
PEEA Treatment								
1	60	57.50	4.95	57.50	90	89.25	5.30	89.25
2	60	59.50	1.73	60.00	90	89.25	2.60	90.00
3	60	58.00	4.90	58.50	90	87.00	8.27	90.75
4	60	58.00	5.90	60.00	90	87.00	11.96	90.00
5	60	59.75	1.89	60.50	90	88.13	3.09	87.75
6	60	59.33	2.08	60.00	90	89.00	3.12	90.00

Notes - The table reports Type A's payoff for each treatment (upper and lower panel) and each role. On the columns it is reported the predicted Nash Equilibrium payoff, and average, standard deviation, and median payoff of the actual data.

Table 5: Type B-division dynamics.

Rounds	Chooser's Payoff				Divider's Payoff			
	NE	Mean	St. Dev.	Median	NE	Mean	St. Dev.	Median
EDDC Treatment								
1	60	72.25	11.95	66.00	66.66	61.50	6.02	64.00
2	60	69.82	9.82	67.50	66.66	64.00	2.28	65.00
3	60	74.59	10.84	72.00	66.66	60.27	7.11	62.00
PEEA Treatment								
1	90	75.25	14.12	72.75	60	56.17	10.87	61.00
2	90	79.20	8.77	76.50	60	62.40	1.95	63.00
3	90	82.75	6.32	83.25	60	59.83	3.92	61.00
4	90	85.50	0.00	85.50	60	61.00	0.00	61.00
5	90	76.93	15.96	85.50	60	55.29	8.40	57.00
6	90	80.25	9.75	81.00	60	59.88	6.31	61.50

Notes - The table reports Type B's payoff for each treatment (upper and lower panel) and each role. On the columns it is reported the predicted Nash Equilibrium payoff, and average, standard deviation, and median payoff of the actual data.

8 Appendix: Instructions

The original instructions were provided on the workstation PC's screens and they are reformatted here to appear in a single pages. For sake of exposition, only type A's instructions are reported (type B's instructions change accordingly), and the interactive sample games are omitted. The original instructions are available on request.

8.1 EDDC Treatment

8.1.1 Welcome

You have been asked to participate in an economics experiment. Please enter the ID number you are given in order to continue the experiment.

8.1.2 Types

You have been asked to participate in an economics experiment. It will be composed of 6 perfectly equal sessions. During the 6 sessions of the experiment you may earn some “experimental points” which will be converted into \$, at a rate of 2 cents for every point, at the end of the experiment. At the beginning of this experiment each of you will be randomly assigned a type (either A and B). In each of the six sessions you will be randomly paired with an agent of the other type. You will not be paired with the same agent more than once. In every session you will not be told who the agent with whom you are paired is both during and after the experiment, and she or he will not be told who you are both during and after the experiment.

In the following screen will appear two lines, the first one will display your ID number, the second one will say you if you are assigned to be a “Type A” or “Type B”. The type of agent you will be said, will remain your type for the whole experiment.

8.1.3 Experiment

The experiment is about dividing a bundle of goods containing one unit of good X and one unit of good Y -each divisible into units- between two types of agents called type A and type B. Every type knows exactly how much he or she values any combination of units of good X and good Y, as well as how much the other type with whom he or she is paired values any share of the two goods he or she is going to receive. Every session of the experiment is conducted as follows: in the beginning each agent is allocated a 50% share of good X and a 50% of good Y (let's call it the "status quo"). Then randomly an agent in each pair will be designated to propose a different combination of shares of the two goods to the other agent (let's call it the "proposed division"). Let's call the former agent "Divider" and the latter "Chooser". The chooser can either accept this proposed division or reject it, in which case the status quo bundle is kept.

At the beginning of each session a screen will appear. It will display if you are assigned to be a "Divider" or a "Chooser" for the starting session.

8.1.4 Divider role

If you are the Divider you will have 3 minutes to decide how much of both goods to give to the Chooser. Since the total amount of both the goods is one unit, the amount that you are to receive is simply the amount to be divided, one unit of each good, minus the amount that you propose to the Chooser.

The two goods are divisible only according to the shares reported on the "Pay-offs' sheet" you are given. Since you know exactly both how much yourself and the chooser value any combination of the two goods, to every division is attached the corresponding payoff (in experimental points) both you get and the chooser gets.

In the payoff sheet you will find, for every feasible combination of the shares of the two goods, what your and Chooser's payoff is in experimental points (notice: you can propose a division only if it appears in one of the rows of the sheet). Because it would never pay to accept a bundle of goods that gives a point-payoff less than the

status quo one, we have eliminated all such bundles from the set of bundles you can decide to take. The status quo bundle is on the last - shaded - row. The first two columns (starting from the left hand side) indicate the shares of goods you would receive (respectively the share of good X and the share of good Y), then the other two columns indicate the shares of goods Type B agent -the chooser- would receive (respectively the share of good X and the share of good Y). Two more columns follow: they indicate respectively the experimental points you will get and those Type B agent will get from any proposed bundle.

Example.

Let's suppose you propose the division written on the row #7 of the payoffs' sheet. At the two first columns you find the share of X you would take (0.10 - or the 10%-) and the share of Y (the whole unit). At the following two columns you find the share of X agent B would receive (0.90) and the share of Y agent B would receive (0.00). In the last two columns you find the experimental points you would receive (93) and those agent B would receive (54). Starting from the very first row in the payoffs' sheet and going down, you will find divisions which give you less and less experimental points.

In order to propose your “proposed division”, you must enter the share of the two goods you are allowed to give to the chooser in the two appropriate boxes (one for good X and one for good Y). At the end of the 3 minutes you are supposed to propose your division. If you didn't enter the division the default share (equal to 0.50 of both the goods) would be kept.

8.1.5 Chooser role

If you are the Chooser, you will have 3 minutes to decide either to accept the proposal made by the counterpart or to reject it (accepting the status quo). - At the end of the 3 minutes you are supposed to reach a decision. If you don't do it the status quo bundle will be kept.

If you wish to accept the proposal of the counterpart you should check the “accept” box. If you do not want to accept the proposal, preferring the status quo division, you should check the “reject” box.

8.2 PEEA Treatment

8.2.1 New Experiment

Now you are participating to one more experiment. You are the same type as in the first experiment. This experiment is identical to that one you performed before, except for the fact that now you are not randomly assigned a role of either divider or chooser. An auction is established to determine who will be the divider.

8.2.2 Auction

You participate to the auction by choosing a bid between 0.05 and 0.50 whose meaning we will describe later. The agent who selects the biggest bid wins the auction and becomes the divider. The other agent with whom he or she is paired loses the auction and becomes the chooser.

The auction procedure is modelled in the following way. Each agent is asked to bid a number between 0.05 and 0.50. The agent who makes the highest bid wins the right to be the divider. The winner doesn't pay the price who bid, but the second highest bid. In other words it will pay the lowest bid between the two pairing agents. If both the agents bid the same number, a divider will be picked up randomly. The list of feasible numbers you can bid is on the auction sheet, which will be explained later.

8.2.3 Bids

The bid indicates the share of both good X and good Y you are willing to transfer from your status quo (0.50 of both X and Y) to the other person's status quo (0.50 of both X and Y) in order to be the divider.

Example 1.

Let's suppose you win the auction by bidding a number equal to 0.20. Let's suppose that the other player bid 0.15. You become the divider, paying a price equal to 0.15. You will perform the experiment you did before with one change: the status quo is not yet fixed at 0.50 of both good X and Y. With a price equal to 0.15 the status quos will be:

- *Your status quo:*
 - 0.35 ($0.50-0.15$) of good X
 - 0.35 ($0.50-0.15$) of good Y
- *Chooser's status quo:*
 - 0.65 ($0.50+0.15$) of good X
 - 0.65 ($0.50+0.15$) of good Y

Example 2.

Let's suppose the other person bid 0.20 , and you bid 0.15 . The other person becomes the "divider", paying a price equal to 0.15 . You becomes the "chooser". You will perform the experiment you did before with one change: the status quo is not yet fixed at 0.50 of both good X and Y . With a price equal to 0.15 the status quos will be:

- *Your status quo:*
 - 0.65 ($0.50+0.15$) of good X
 - 0.65 ($0.50+0.15$) of good Y
- *Divider's status quo:*
 - 0.35 ($0.50-0.15$) of good X
 - 0.35 ($0.50-0.15$) of good Y

8.2.4 Auction's price

In order to decide the number to bid, you have to consider the potential prices you are going to pay. - Let's take the Auction Sheet now -.

In this sheet you will find two tables. They say how the status quo of both agent A and agent B (and the corresponding payoffs) would change for every price at which the auction is paid. The table on the top indicates the values of the status quo's payoffs when agent A wins the auction, the table on the bottom refers to agent B. Let's consider the first table: the first two columns report the new status quo for agent A (who made the highest bid, becoming the divider), while the other two columns

report the new status quo for agent B. The last two columns report the corresponding points attached with the new status quo.

Note: When you win the right to be the divider, please check the point payoffs the chooser would get by the status quo corresponding to the price you have to pay. Be sure that any offer you propose gives her or him at least the point payoffs of the status quo.

Example.

Let's suppose you are the divider, receiving that right at a price equal to 0.05. The status quo of the chooser will be 0.55 of X + 0.55 of $Y = 44$ points. You should check that your offer gives to the chooser a payoff greater than 44.

Once the auction has determined the divider, the game proceeds as before.

Row	shares for A		shares for B		Profit for A	Profit for B
	x	y	x	y		
1	0.30	1.00	0.70	0.00	99.00	42.00
2	0.25	1.00	0.75	0.00	97.50	45.00
3	0.20	1.00	0.80	0.00	96.00	48.00
4	0.35	0.95	0.65	0.05	96.00	40.00
5	0.15	1.00	0.85	0.00	94.50	51.00
6	0.30	0.95	0.70	0.05	94.50	43.00
7	0.10	1.00	0.90	0.00	93.00	54.00
8	0.25	0.95	0.75	0.05	93.00	46.00
9	0.05	1.00	0.95	0.00	91.50	57.00
10	0.20	0.95	0.80	0.05	91.50	49.00
11	0.35	0.90	0.65	0.10	91.50	41.00
12	0.00	1.00	1.00	0.00	90.00	60.00
13	0.15	0.95	0.85	0.05	90.00	52.00
14	0.30	0.90	0.70	0.10	90.00	44.00
15	0.10	0.95	0.90	0.05	88.50	55.00
16	0.25	0.90	0.75	0.10	88.50	47.00
17	0.05	0.95	0.95	0.05	87.00	58.00
18	0.20	0.90	0.80	0.10	87.00	50.00
19	0.35	0.85	0.65	0.15	87.00	42.00
20	0.00	0.95	1.00	0.05	85.50	61.00
21	0.15	0.90	0.85	0.10	85.50	53.00
22	0.30	0.85	0.70	0.15	85.50	45.00
23	0.10	0.90	0.90	0.10	84.00	56.00
24	0.25	0.85	0.75	0.15	84.00	48.00
25	0.40	0.80	0.60	0.20	84.00	40.00
26	0.05	0.90	0.95	0.10	82.50	59.00
27	0.20	0.85	0.80	0.15	82.50	51.00
28	0.35	0.80	0.65	0.20	82.50	43.00
29	0.00	0.90	1.00	0.10	81.00	62.00
30	0.15	0.85	0.85	0.15	81.00	54.00
31	0.30	0.80	0.70	0.20	81.00	46.00
32	0.10	0.85	0.90	0.15	79.50	57.00
33	0.25	0.80	0.75	0.20	79.50	49.00
34	0.40	0.75	0.60	0.25	79.50	41.00
35	0.05	0.85	0.95	0.15	78.00	60.00
36	0.20	0.80	0.80	0.20	78.00	52.00
37	0.35	0.75	0.65	0.25	78.00	44.00
38	0.00	0.85	1.00	0.15	76.50	63.00
39	0.15	0.80	0.85	0.20	76.50	55.00
40	0.30	0.75	0.70	0.25	76.50	47.00
41	0.10	0.80	0.90	0.20	75.00	58.00
42	0.25	0.75	0.75	0.25	75.00	50.00
43	0.40	0.70	0.60	0.30	75.00	42.00
44	0.05	0.80	0.95	0.20	73.50	61.00
45	0.20	0.75	0.80	0.25	73.50	53.00
46	0.45	0.65	0.55	0.35	72.00	40.00
47	0.10	0.75	0.90	0.25	70.50	59.00
48	0.25	0.70	0.75	0.30	70.50	51.00
49	0.40	0.65	0.60	0.35	70.50	43.00
50	0.05	0.75	0.95	0.25	69.00	62.00
51	0.20	0.70	0.80	0.30	69.00	54.00
52	0.35	0.65	0.65	0.35	69.00	46.00
53	0.00	0.75	1.00	0.25	67.50	65.00
54	0.15	0.70	0.85	0.30	67.50	57.00
55	0.30	0.65	0.70	0.35	67.50	49.00
56	0.45	0.60	0.55	0.40	67.50	41.00
57	0.10	0.70	0.90	0.30	66.00	60.00
58	0.25	0.65	0.75	0.35	66.00	52.00
59	0.40	0.60	0.60	0.40	66.00	44.00
60	0.05	0.70	0.95	0.30	64.50	63.00
61	0.20	0.65	0.80	0.35	64.50	55.00
62	0.35	0.60	0.65	0.40	64.50	47.00
63	0.00	0.70	1.00	0.30	63.00	66.00
64	0.15	0.65	0.85	0.35	63.00	58.00
65	0.30	0.60	0.70	0.40	63.00	50.00
66	0.45	0.55	0.55	0.45	63.00	42.00
67	0.10	0.65	0.90	0.35	61.50	61.00
68	0.25	0.60	0.75	0.40	61.50	53.00
69	0.40	0.55	0.60	0.45	61.50	45.00
70	0.05	0.65	0.95	0.35	60.00	64.00
71	0.20	0.60	0.80	0.40	60.00	56.00
72	0.35	0.55	0.65	0.45	60.00	48.00
73	0.50	0.50	0.50	0.50	60.00	40.00

Figure 13: Type A's Payoff sheet

AUCTION SHEET

If agent A win the competition	New Status quo		New Status quo		Associated Payoffs of A and B	
	Agent A		Agent B		A	B
	x	y	x	y		
price=0.45	0.05	0.05	0.95	0.95	6.00	76.00
price=0.40	0.10	0.10	0.90	0.90	12.00	72.00
price=0.35	0.15	0.15	0.85	0.85	18.00	68.00
price=0.30	0.20	0.20	0.80	0.80	24.00	64.00
price=0.25	0.25	0.25	0.75	0.75	30.00	60.00
price=0.20	0.30	0.30	0.70	0.70	36.00	56.00
price=0.15	0.35	0.35	0.65	0.65	42.00	52.00
price=0.10	0.40	0.40	0.60	0.60	48.00	48.00
price=0.05	0.45	0.45	0.55	0.55	54.00	44.00
price=0.00	0.50	0.50	0.50	0.50	60.00	40.00

If agent B win the competition	New Status quo		New Status quo		Associated Payoffs of A and B	
	Agent A		Agent B		A	B
	x	y	x	y		
price=0.45	0.95	0.95	0.05	0.05	114.00	4.00
price=0.40	0.90	0.90	0.10	0.10	108.00	8.00
price=0.35	0.85	0.85	0.15	0.15	102.00	12.00
price=0.30	0.80	0.80	0.20	0.20	96.00	16.00
price=0.25	0.75	0.75	0.25	0.25	90.00	20.00
price=0.20	0.70	0.70	0.30	0.30	84.00	24.00
price=0.15	0.65	0.65	0.35	0.35	78.00	28.00
price=0.10	0.60	0.60	0.40	0.40	72.00	32.00
price=0.05	0.55	0.55	0.45	0.45	66.00	36.00
price=0.00	0.50	0.50	0.50	0.50	60.00	40.00

Figure 14: Auction Sheet

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