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The Fisherman's Problem: Exploring the tension between cooperative and non-cooperative concepts in a simple game

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Abstract

We introduce and experiment the Fisherman's Game in which the application of economic theory leads to four different benchmarks. Non-cooperative sequential rationality predicts one extreme outcome while the core (which coincides with the competitive market equilibrium) predicts the other extreme. Intermediate, disjoint outcomes are predicted by fairness utility models and the Shapley value. None of the four benchmarks fully explains the observed behavior. However, since elements of both cooperative and non-cooperative game theory are crucial for organizing our data, we conclude that effort towards bridging the gap between the various concepts is a promising approach for future economic research.

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1. Introduction

Every early afternoon, when the fisherman returns to the harbor after a day of hard work on the sea, he puts up his fish for sale. One after the other, potential customers come by to examine the fish and to bargain a good price. For years and years the fisherman sells his day's catch in this manner without ever perceiving that he has a problem. Then, one day, late on a September afternoon, a peculiar tourist arrives at the fisherman's sales stand. Even before the fisherman can praise his catch, this special customer says: "I offer you three cents for your fish and if you're rational, you should accept this offer immediately." The stunned fisherman thinks a second and replies: "No, I'll just wait and sell it to someone else." The customer, clearly familiar with non-cooperative game theory, gently explains: "But, it's already late in the afternoon. At this time you can at most expect one or two more potential customers to arrive after me. The last person won't give you more than a single cent, since he knows that your dead fish will be rotten tomorrow. The one before might offer you two cents, just to make sure you accept – and you will, because two cents are more than one. No need to say that my offer of three cents is quite generous under these circumstances." The fisherman is convinced by the intriguing logic behind this argument and wraps the fish into paper.

After having realized his serious economic problem, the fisherman decides to get professional help. He enrolls in the local university's economics program. In the very first class he visits, he is stunned by economic reasoning for the second time. Here, while learning about how markets work, he hears that a supplier receives practically all market surplus, if his supply is smaller than the demand he is facing. After class, the fisherman walks up to the professor, describes his problem, and asks for clear economic advice. The professor is reluctant to answer, but then reveals: "Well, it all depends on which branch of economic theory you are applying. If you apply non-cooperative game theory to your problem, you're bound to give away your fish almost for nothing. But, if you trust cooperative game theory, you can ask for the highest price your customers are willing to pay, since this is the only allocation in the core of your game and corresponds to competitive market equilibrium. I guess, your problem is something for economists to study more intensely..."

The story of the fisherman just goes to show that economists have done little so far to bridge the gap between their two most predominant equilibrium concepts: the *strategic equilibrium* of non-cooperative game theory and the (traditional) *competitive (market) equilibrium* that is closely related to the *core*, the central solution concept of cooperative game theory. It seems that in the profession the concepts are generally not perceived as "competing", but rather as "dividing". With very rare exceptions, most work in economic theory is either in the spirit of the one or the other concept. Sometimes authors deliberate on the choice of a concept, but more often no reasons are put forward. Furthermore, the debate between cooperative and non-cooperative game theorists used to be much more audible in the early days of game theory. Then, for a long time, the two approaches seem to have found a form of peaceful coexistence with very little interaction between them. Only relatively late, bridging the gap between the two concepts has become an issue again among game

theorists. A main focus has been to identify conditions under which cooperative benchmarks can be implemented as equilibrium outcomes of strategic games. For example, Gul (1989) shows conditions under which the payoffs associated with the efficient subgame perfect equilibrium converge to the players' Shapley values. Another example is given by Perry and Reny (1994), who introduce a non-cooperative continuous-time bargaining game in which only core allocations can be sustained as stationary subgame perfect equilibria.¹

These theoretical results, however, are based on very specific assumptions. In general, it is possible to devise economic institutions that allow any of various constellations of conclusions derived from cooperative and non-cooperative concepts: The two sets of predicted outcomes may coincide, they may be disjoint, or one may be partially or wholly contained in the other. When the two sets coincide, this is the fortunate case in which we are quite confident to make the "right" theoretical prediction. Empirically, a situation of this kind was studied in the laboratory experiments by Roth, Prasnikar, Okuno-Fujiwara, and Zamir (1991) and Prasnikar and Roth (1992). Both studies analyze a posted-offer market game with nine buyers and one seller. The subgame perfect equilibrium as well as the competitive equilibrium (which is also the unique core allocation) predict the same very extreme outcome in which the seller gets *all* the surplus leaving zero to all other nine players. In fact, this prediction was strongly supported in all sessions of the two experimental investigations.

But, what if the predictions of the different concepts fall apart, as in the case of the Fisherman's Problem? In such a situation, it seems that economic theory has no clear prediction. Furthermore, there are no experimental studies known to us addressing this question. In this paper, we present experimental evidence on a game concerned with the Fisherman's Problem. In our game, the fisherman has only one fish to sell and the buyers make take-it-or-leave-it offers. The predictions of the core (Aumann, 1964; Gillies, 1959; Scarf, 1967; Shapley, 1959; Shubik, 1959) and of non-cooperative sequential rationality (Kreps & Wilson, 1982; Selten, 1965, 1975) do not only diverge in this game, they are moreover on the extreme ends of the range of possible outcomes, with the core allocating almost all surplus to the fisherman, and sequential rationality giving almost all surplus to the first customer. Between these boundaries we consider two other benchmarks. The Shapley value (Shapley, 1953) is of interest because in some sense it reflects the power allocation between the players. In our game, the Shapley value provides a benchmark that gives the fisherman a great share of the surplus, but not as much as he receives in the core. An even smaller share than given by the Shapley value benchmark is allocated to the fisherman by non-cooperative game models incorporating fairness utility. These models (e.g. Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999) contain psychological parameters linking preferences for fair allocations to monetary payoffs. Depending on the parameters, a range of outcomes rather than a single one can be in accordance with these models.

¹ For more detailed insights into the implementation of cooperative solutions as outcomes of non-cooperative equilibrium play refer to Gale (2000) and Osborne and Rubinstein (1990).

This range, however, has a distinct upper bound allocating about half of the surplus to the fisherman.

None of the four benchmarks can fully explain the behavior observed in our experiment. Both competition and fairness considerations play a non-negligible role. Furthermore, some aspects of our data hint at the importance of sequential rationality. Thus, our results underline the behavioral relevance of both cooperative and non-cooperative concepts, and call for a greater effort to link up the concepts in enhanced theories.

2. The Fisherman's Game

The *Fisherman's Game* is an extension of the classical ultimatum game (Güth, Schmittberger, & Schwarze, 1982) with three (potential) proposers P_1 , P_2 , and P_3 and one responder R . The three proposers sequentially propose an allocation of a cake C to the responder. First, P_1 proposes an allocation $a_1 = (x_1, C - x_1)$ of C to R , where x_1 denotes the proposed payoff for the responder R and $C - x_1$ denotes the own payoff desired by P_1 . The game ends if R accepts the proposal of P_1 . If P_1 's proposal is rejected by R , then P_2 proposes an allocation $a_2 = (x_2, C - x_2)$ of C to R . If R accepts P_2 's proposal, the game ends. Otherwise, if R also turns down P_2 's proposal, it is P_3 's turn to propose an allocation $a_3 = (x_3, C - x_3)$ of C to R . If R accepts the proposal of any proposer P_i , R receives x_i , P_i receives $C - x_i$, and each of both other proposers receives 0. If R rejects all three proposals all four players receive 0. We consider the game with discrete choices and denote the smallest money unit by μ , where $\mu \ll C/3$.² Depending on the information sets of the proposers, two variants of the Fisherman's Game are considered. In the *Fisherman's Game with complete information* each proposer P_i is informed about all proposals made to the responder. In the *Fisherman's Game with imperfect information* each proposer only knows his own proposals. Obviously, later stage proposers can infer that earlier offers have been rejected by the mere fact that they have a move.

We consider four benchmarks in this study, two from cooperative game theory and two from non-cooperative game theory, for this game. In the following subsections, we describe these benchmarks in more detail, and apply them to our game.

2.1. Cooperative solution concepts

The core of a game (Aumann, 1964; Gillies, 1959; Scarf, 1967; Shapley, 1959; Shubik, 1959) contains all payoff profiles that are stable in the sense that no (sub)coalition can profitably deviate and achieve a higher payoff for all of its members. In the core of the competitive ultimatum game the responder either receives the total cake

² Obviously, this game can be extended to any number of proposers. The classical ultimatum game is the special case of one proposer. We consider the game with three proposers, because in this case the theoretical benchmarks are spread well across the range of possible outcomes.

C and leaves nothing for the proposers, or the responder gets $C - \mu$ and only one of the proposers receives a smallest money unit μ . Thus, if we assume that the proposers constitute the demand side of a competitive market and the responder is the supplier, the core describes the set of competitive market equilibria.³

Roughly speaking, the Shapley value (Shapley, 1953) measures each player's expected marginal contribution to a (randomly specified) coalition he could be contained in. If we apply this concept to the Fisherman's Game, the allocations are less extreme than in the core. The responder receives three quarters of the cake and each of the proposers receives one-third of the remaining quarter. Note that in both solution concepts of cooperative game theory, the responder is the "strongest" player receiving a much larger portion of the cake than any of the proposers.

2.2. Non-cooperative solution concepts

In contrast to the predictions made by the concepts from cooperative game theory, the responder is the weak player in the non-cooperative solution concepts, who has to leave almost the whole cake to one of the proposers. Suppose that each proposer P_i is completely informed about the proposal(s) of the proposer(s) who have decided before P_i . This Fisherman's Game with complete information has multiple subgame perfect equilibria. All these equilibria, however, lead to virtually the same payoff distribution. In order to deduce the bounds for the responder's equilibrium payoff, we follow a simple backward induction argument. If P_3 proposes at least the smallest money unit μ to R , then R will accept. If P_3 offers 0, the R is indifferent between accepting and rejecting the offer. Thus, in every subgame perfect equilibrium P_3 either offers 0 or μ to R , who accepts the proposal. Anticipating this, R will accept each proposal of P_2 that yields at least 2μ for R . However, there are also subgame perfect equilibria in which P_2 offers 0 or μ to the responder and the responder accepts the proposal. Thus, in every subgame perfect equilibrium P_2 either offers 0, μ , or 2μ to R , who accepts the proposal. Therefore, R will accept each proposal of P_1 that yields at least 3μ for R . Moreover, there are also subgame perfect equilibria in which P_1 offers 0, μ , or 2μ to R . Thus, in every subgame perfect equilibrium P_1 either offers 0, μ , 2μ , or 3μ to R . Hence, the lower bound for the responder's equilibrium payoff is 0 and the upper bound is 3μ .

Now, suppose that each proposer P_i is not informed about the proposal(s) of the proposer(s) who have decided previously. This means that the second and third proposer can infer that the responder rejected the previous proposal(s) from the fact that it is their turn to decide. However, they do not know which amount was actually proposed by the previous proposer(s). The Fisherman's Game with imperfect information has multiple sequential equilibria, which lead virtually to the same payoff distribution. Again, we derive an upper bound for the responder's equilibrium payoff by assuming that R will reject a proposal every time he/she is indifferent between

³ Clearly, subsets of the core, such as the *nucleolus* and the *least core*, also give almost all surplus to the responder.

accepting and rejecting. Then, in equilibrium, proposer P_3 proposes $a_3 = (\mu, C - \mu)$. Proposer P_2 proposes in equilibrium $a_2 = (2\mu, C - 2\mu)$ and proposer P_1 proposes $a_1 = (3\mu, C - 3\mu)$. Thus, on the equilibrium path R accepts the proposal $(3\mu, C - 3\mu)$ of the first proposer and receives a payoff of 3μ . This payoff is the upper bound for the responder's equilibrium payoff. Evidently, the lowest equilibrium payoff of R is zero.

Recently, several attempts have been made to incorporate fairness utility into the non-cooperative game theory framework. Two of the most influential approaches are those by Bolton and Ockenfels (2000) and Fehr and Schmidt (1999).⁴ In both cases, the players' utilities are assumed to be increasing not only in the own monetary payoff, but also in "fairness". Both models basically relate fairness to the equal shares benchmark. Next to the increasing utility in their own monetary payoffs, players' utilities also increase as the allocation approaches equal shares.

Note that the Fisherman's Game is a game in extensive form, in which the number of potentially active players decreases from stage to stage. At any given time, only two players are involved in each stage, i.e. only these two have actions and can receive positive payoffs in that stage. This implies that there are essentially two ways of defining "equal shares". On the one hand, an equal share between the two currently active players can be considered, which would allocate half of the cake to the responder and half to the currently active proposer. On the other hand, an equal share can be defined as equal expected payoffs for all four players, i.e. an expected payoff of one-fourth of C for each. A number of procedures are conceivable for achieving such an allocation with equal expected shares. For example, each proposer could offer one-fourth of the cake, whenever it is his turn, while the responder always accepts this offer from the first proposer. Since each of the three proposers has the same probability for being first in line, this procedure leaves one-fourth of the cake for each player, in expectations.⁵

In the case in which only the active players are considered, fairness utility models predict that the last proposer offers no more than 50% of C . To understand why 50% is the maximum possible proposal, note that the responder will never reject an offer of 50% in the last stage. This is so, because the total utility is composed of the pecuniary and the fairness utility. At offers below 50% of C , it may be worthwhile for a responder to reject, because the fairness utility loss may exceed the pecuniary utility gain from accepting. Offers greater or equal to 50% of C , however, are certainly accepted, because receiving 50% of C is not only better than receiving zero after rejection, but it also maximizes fairness utility. Thus, giving away more than 50% would not make any sense from the point of view of the last proposer. By backward induction, it follows that in any equilibrium with fairness utilities the maximum offer made

⁴ The model by Bolton and Ockenfels (2000) has its origins in Bolton (1991). Other fairness utility models have been proposed by Dufwenberg and Kirchsteiger (1998), Falk and Fischbacher (1998) and Rabin (1993).

⁵ Obviously, none of these equal shares allocations is supported by the traditional non-cooperative equilibrium concept, if the players are purely self-interested and only motivated by monetary payoffs.

by the first proposer is $\frac{1}{2}C + 2\mu$. Which offer in the range from zero to this maximum is predicted depends on the relative strength of the fairness utility component.

In the case, in which all four players are considered, the fairness utility models predict that the last proposer offers no more than 25% of C . As in the previous case, the responder will never reject an offer of 25% of C , because receiving 25% of C is not only better than receiving zero after rejection, but it also maximizes his fairness utility. By backward induction, it follows that in any equilibrium with fairness utility the maximum offer made by the first proposer is $\frac{1}{4}C + 2\mu$. Note that in this case fairness is only achieved in expectations and only if we assume that each proposer has an equal chance of receiving $\frac{3}{4}$ of the cake, e.g. by randomly assigning the proposer positions as in our experiment.

2.3. Relation of the Fisherman's Game to other games

To our knowledge this is the first systematic experimental study concerned with the evaluation of these competing equilibrium concepts. However, an interesting benchmark for our work is supplied by Roth et al. (1991) and Prasnikar and Roth (1992). They study the "Market Game" with nine proposers who *simultaneously* propose an allocation to a single responder.⁶ The responder may accept or reject the highest proposed offer. The cooperative game theory benchmarks give – as in the case of the Fisherman's Game – virtually the entire cake to the responder. In contrast to the case of the Fisherman's Game, however, non-cooperative game theory predicts the same extreme solution of the market game as predicted by the cooperative benchmarks. Thus, in the Market Game all game theoretic benchmarks virtually fall together, whereas in the Fisherman's Game they are spread over the entire range of possible outcomes. The unambiguous game theoretic prediction in the Market Game is consistently observed in all experimental sessions and in all four countries.

Furthermore, the Fisherman's Game is in some ways related to the Chain-Store Game (Selten, 1978). In the Chain-Store Game, the chain-store player meets a fixed and finite number of potential entrants, one after the other, in a sequence of independent stages. In each stage, the potential entrant decides whether or not to enter the market. If the entrant stays out, the chain-store receives its monopoly payoff. Otherwise, the chain-store can choose to "fight" or to "cooperate". Although "fighting" is dominated by "cooperation" in each stage, the chain-store may choose to "fight" early on, in order to deter market entrance in later stages. The common feature of the two games is that one player meets a number of other players sequentially with a similar decision situation in each stage. This means that the repeatedly deciding player can – to some extent – build up a reputation for "tough" play in both games. The important difference, however, is that in the Fisherman's Game payoffs can only be achieved in one of the stages, after which the game immediately ends.

⁶ Güth, Marchand, and Ruilliere (1997) study a market game with responder competition in which solutions from cooperative as well as non-cooperative game theory give almost all the cake to the proposer.

This leads to an extreme competition between the proposers, who are – in principle – competing for the same cake. In contrast, since the payoff possibilities in each stage of the Chain-Store Game are independent of the outcome of the other stages, there is no competition between the potential entrants in that game.

3. Experimental design and procedure

Using a 2×2 factorial design, the experiment was conducted with the two informational settings at two locations, namely at the University of Bonn (*Laboratorium für experimentelle Wirtschaftsforschung*) and at the Hebrew University in Jerusalem (*RatioLab*). Our two subject pools at the two locations consisted of students, mainly from economics, law, and psychology. The experimental software was written using *RatImage* (Abbink & Sadrieh, 1995). The program was written such that either of the two languages, German or Hebrew, could be selected.

In the *open treatment*, the game with perfect information was played. In this setting all players were informed about all proposals that were made, immediately after they were made. In the second informational setting, the *covered treatment*, the game with imperfect information was played, i.e. proposers were not informed about the proposals made by other proposers. We conducted six sessions per cell, i.e. per treatment and subject pool. Twelve participants took part in each session, which adds up to 144 participants at each location. Since all 12 subjects interacted in each session, all our independent observations are on session level.

The written instructions⁷ were read aloud by the experimenter. After this, the participants drew cards that determined the cubicles in which they were seated. At the beginning of the experiment, each cubicle had been randomly assigned a role, with nine proposers and three responders in each session. The roles of the subjects as being proposer or responder were not changed during the whole session.

The experiment consisted of 36 rounds. Before each round, three proposers and one responder were randomly matched to form a group. Thus, there were three groups of four subjects in each round. The ordering of the three proposers in a group was randomly assigned for each round. It was equally likely for each proposer to become the first, the second, or the third proposer. This was known to the subjects.

The cake size was 1000 points. Allocations were proposed in the form of an offer to the responder, i.e. proposers specified the number of points they were willing to offer to the responder. The smallest money unit was a point. All offers were transmitted to the responder. In the open treatment, each offer was also transmitted to the other two proposers. The responder could accept or reject an offer. If the responder

⁷ We aimed to give the participants at both places instructions that were as close as possible in terms of contents and wording. We, therefore, first wrote the instructions in English. Then we translated them into German and Hebrew. Translators not involved in the first translation translated them back into English. The back-translations were compared to the original text. In case of deviations the translations were adjusted. This procedure was repeated until the original instructions and the back-translations showed practically no more differences.

rejected the first or the second offer, no payments were made and it was the turn of the next proposer to suggest a division of the 1000 points. If the third offer was rejected, the round ended with zero payoffs to all four players. If the responder accepted an offer, the responder and the proposer who made the offer received the corresponding payoffs, while the other two proposers received no payoff for this round. The final payoffs of the subjects were equal to the sum of their round payoffs over all 36 rounds. The experimental exchange rates, DM 1 for 400 points and NIS 1 for 200 points, were adjusted in a way that total earnings were comparable in terms of teaching assistants' average hourly wages at each location. The foreign currency exchange rates at the time of the experiment were roughly US-\$0.66 for DM 1 and US-\$0.31 for NIS 1.

4. Results

The main focus of our data analysis is on comparing the results to the benchmarks discussed above. In this context, we look at the payoff allocations as well as proposal and acceptance behavior. Furthermore, we study treatment and subject pool differences.

4.1. Payoff allocations

Table 1 summarizes the predictions made by the four concepts for our parameter set. Notice that the predictions of the core and the Shapley value need some interpretation. The only allocations in the core give the responder 1000 or 999. In the latter case, one of the proposers receives the smallest money unit $\mu = 1$. In the table, we present the expected payoff, if the three proposers were equally likely to receive the smallest money unit. Also the Shapley value can be interpreted as an expected value over plays, since in each play at most one proposer can obtain a positive payoff. Sequential rationality only predicts a small range of outcomes. The exact predictions of fairness utility depend on unobservable parameters. All allocations giving the responder more than 502, however, are excluded. Both cooperative benchmarks fall into the range excluded by fairness utility. Sequential rationality and the core make extreme predictions in opposite directions.

Fig. 1 shows the average responder payoffs for each of the four cells. For the purpose of comparison the four benchmarks are indicated in the graph. In all four cells, the average responder payoffs are in the upper half of the range and, thus, fall outside the range of both non-cooperative benchmarks. However, they are not as high as predicted by either of the cooperative concepts.⁸ Therefore, a simple explanation by any of the four benchmarks is not at hand.

It is noteworthy that responders in our experiment earn substantially more than in the standard ultimatum game. Apart from very rare exceptions responders in the

⁸ If we take the median instead of averages, the results are not qualitatively different.

Table 1

Predicted range of responder’s and proposers’ payoffs for the parameters $C = 1000, \mu = 1$

	Core	Shapley value	Fairness utility	Seq. rationality
Responder	$\pi_C \in \{999, 1000\}$	750	$\pi_F \in \{0, \dots, 502\}$	$\pi_S \in \{0, \dots, 3\}$
Proposer 1	$(1000 - \pi_C)/3$	250/3	$1000 - \pi_F$	$1000 - \pi_S$
Proposer 2	$(1000 - \pi_C)/3$	250/3	0	0
Proposer 3	$(1000 - \pi_C)/3$	250/3	0	0

The predictions of the core and the Shapley value should be interpreted as averages over plays, since in each play at most one proposer can obtain a positive payoff.

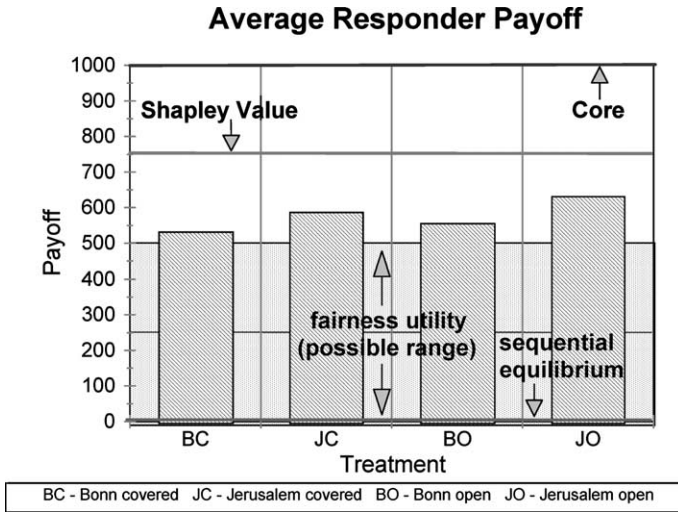


Fig. 1. Observed and predicted average responder payoff.

standard ultimatum game never receive more than half of the cake. This is especially remarkable, because our game provides an alternative equal split norm that could be expected to drive responders payoffs further down towards 25% of the cake.

Fig. 1 further shows that in all cells, the average responder payoffs are greater than half of the cake. Thus, the outcomes in our game are further away from the predictions of non-cooperative game theory than in the standard ultimatum game. Therefore, we have reason to believe that the competition between proposers creates a behavioral tension that is not captured by the non-cooperative benchmarks.

4.2. Proposal behavior

Fig. 2 shows the frequency distribution of offers (in intervals of 50 points each) for the aggregate data of all treatments and subject pools. One can immediately see that the distribution of first and second proposer offers are skewed upwards, i.e. towards values above 500, while the distribution of third proposer offers is skew downward,

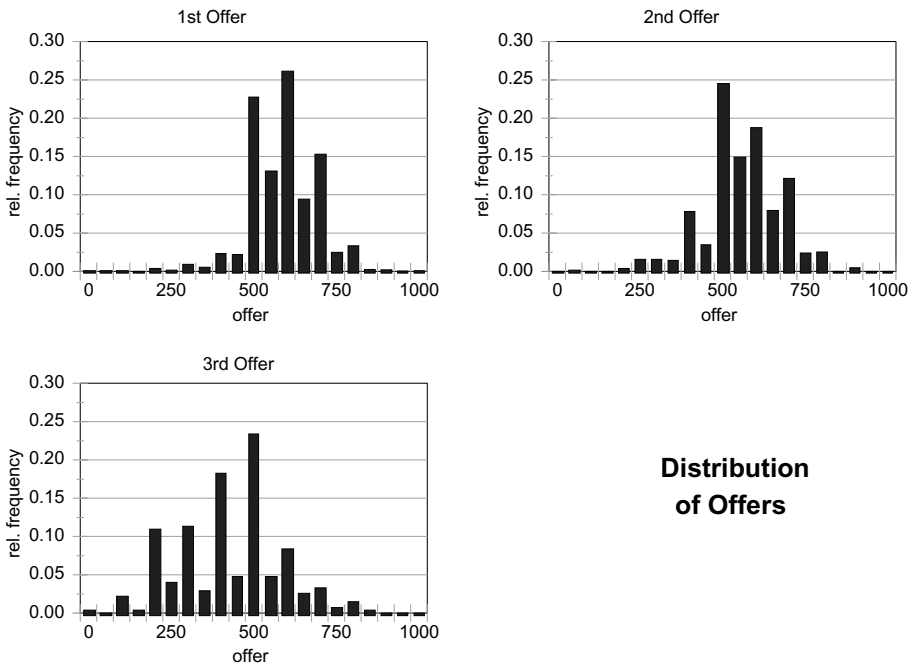


Fig. 2. Distribution of observed offers.

i.e. towards values below 500. Nevertheless, in all three distributions, offers around the equal split between the current proposer and the responder, i.e. at around 500, are predominant. Offers near the equal split between all four players (i.e. 250 for the responder) are rarely chosen. Even lower offers hardly ever occur.

Table 2 contains the average offers of the first, the second and the third proposer. The average first proposer offer is clearly above 500 in all four cells, with even less than 7% of all cases below 500. Although the average second proposer offer is also above 500 in three of four cells, the second proposers tend to make lower offers than the first proposers. Nevertheless, with only about 16% of all cases below 500 and more than 60% of all cases above 500, the majority of second proposers is willing to give more than they ask for themselves. In the last stage, the average third proposer offer is clearly below the equal split, with more than 55% of the offers below 500. The overall average third proposer offer of 42% is comparable to standard results of ultimatum game experiments.⁹ This seems to indicate that the last stage subgame, which has the strategic structure of an ultimatum game, is perceived by proposers in a similar way as the ultimatum game. Given subjects actually play the last stage subgame ignoring the history of play as well as the existence of the

⁹ See e.g. Camerer and Thaler (1995), Güth (1995), Güth et al. (1982), Güth and Tietz (1990), or Thaler (1988).

Table 2
Average offers

Average offer	Jerusalem covered	Bonn covered	Jerusalem open	Bonn open	Overall
First offer	593.78	533.17	631.94	567.03	581.48
Second offer	562.51	498.79	597.34	547.84	551.62
Third offer	411.76	373.65	481.71	415.84	420.74
$\Delta_1 = \text{first} - \text{second offer}$	31.27***	34.37***	34.60**	19.19*	29.86
$\Delta_2 = \text{second} - \text{third offer}$	150.75***	125.14***	115.63***	132.00***	130.88
$\Delta_2 - \Delta_1$	119.48***	90.77***	81.03*	112.81***	101.02

***Significantly greater than 0. Wilcoxon signed ranks test, $\alpha = 2\%$, one-tailed.

**Significantly greater than 0. Wilcoxon signed ranks test, $\alpha = 5\%$, one-tailed.

*Greater than 0 (weakly significant). Wilcoxon signed ranks test, $\alpha = 10\%$, one-tailed.

non-active players (i.e. the first and second proposer), our observations add to the behavioral relevance of the concept of backward induction.

Furthermore, the concept of backward induction also seems to receive support from our data. Table 3 contains the average overall and accepted offers made in each stage of the game for every session. An inspection of the table reveals that in 21 of 24 sessions, the average overall offers have a strictly declining pattern from the first to the third proposal.¹⁰ The Wilcoxon signed ranks test rejects the null hypothesis of equally high first and second proposer offers as well as that of equally high second and third proposer offers in favor of a declining pattern, in all cases. The significance levels and the average differences between offers at consecutive stages are shown in Table 2.

The descending sequence of offers suggests that proposers in the second stage make additions to the anticipated third stage offers and proposers in the first stage make additions to the anticipated second stage offers. As Table 2 and Fig. 3 show, the first and second stage proposers, however, add substantially more than the smallest money unit to the actual next stage average offer. This may be the case because of one of the following two reasons: Either subjects greatly overestimate the next stage offer, due to competition, or they have a reasonable expectation of the next stage offer, but make a large addition in the hope to increase the probability of acceptance.

One interesting observation is that the difference between the first and the second offer is significantly smaller than the difference between the second and the third offer (see Table 2 and Fig. 3). This difference reflects the fact that the marginal disadvantage of competition is decreasing in the number of competitors. Going from a one proposer situation to a two proposer situation creates a disadvantage that is on average more than four times as large as the disadvantage from going from a two pro-

¹⁰ The pattern of average accepted offers is very similar to that of the average overall offer. In 20 of 24 sessions, the average accepted offers decline from stage to stage. In three cases, the average second proposer offer is greater than both the average first and third proposer offers. In only one case, the average third proposer offer is greater than the preceding average offers.

Table 3
Average overall and accepted offers on every stage

Session			First proposer		Second proposer		Third proposer	
			All	Accepted	All	Accepted	All	Accepted
C	J	1	636.59	689.36	619.32	708.39	422.22	476.92
		2	553.71	574.22	523.06	550.00	366.67	400.00
		3	615.60	654.46	538.58	595.73	426.47	426.47
		4	588.19	622.86	526.32	552.00	403.85	427.27
		5	622.45	667.38	602.47	626.24	435.71	477.78
		6	546.11	552.42	478.46	502.00	233.33	200.00
		∅	593.78	618.74	562.51	602.41	411.67	443.27
	B	1	575.15	609.11	552.36	564.84	440.00	500.00
		2	530.81	541.54	483.39	510.07	416.67	475.00
		3	495.31	522.68	446.19	501.82	335.00	407.14
		4	512.44	526.06	481.68	509.58	404.25	430.10
		5	543.15	558.49	494.95	513.00	356.43	420.00
		6	542.15	588.85	506.95	528.32	338.00	414.00
		∅	533.17	555.60	498.79	527.66	373.65	430.34
O	J	1	525.00	538.35	543.97	559.05	325.00	350.00
		2	664.86	716.90	630.89	652.71	412.50	516.67
		3	630.87	675.93	560.90	614.50	495.43	508.18
		4	637.04	666.04	592.73	640.00	443.33	486.36
		5	657.27	684.36	587.00	694.07	586.88	645.00
		6	676.60	744.06	655.20	712.09	502.73	533.00
		∅	631.94	668.49	597.34	647.70	481.71	526.22
	B	1	520.00	586.31	469.84	542.70	288.50	340.78
		2	564.12	596.34	532.04	543.16	438.13	469.76
		3	666.34	695.54	634.63	665.69	542.78	630.83
		4	518.67	552.59	525.08	552.81	400.20	412.50
		5	519.00	534.83	522.78	552.37	412.50	562.50
		6	614.07	644.27	600.04	636.15	437.37	492.50
		∅	567.03	599.33	547.84	586.66	415.84	473.43

C: covered treatment; O: open treatment; B: Bonn session; J: Jerusalem session.

poser situation to a three proposer situation (proposer two on average offers 130.88 more than proposer three while proposer one offers on average 29.86 more than proposer two). Note that a difference in the marginal disadvantage is not predicted by standard non-cooperative game theory which predicts a marginal disadvantage of (at most) one smallest money unit on any stage.

4.3. Acceptance behavior

Extremely low offers are practically never successful. Fig. 4 shows that first and second offers below 500 are rejected in more than 80% of the cases. In contrast, first and second offers above 500 are rejected only in about 20% of the cases. The figure also clearly shows that the responders are not only responsive to the size of the offer,

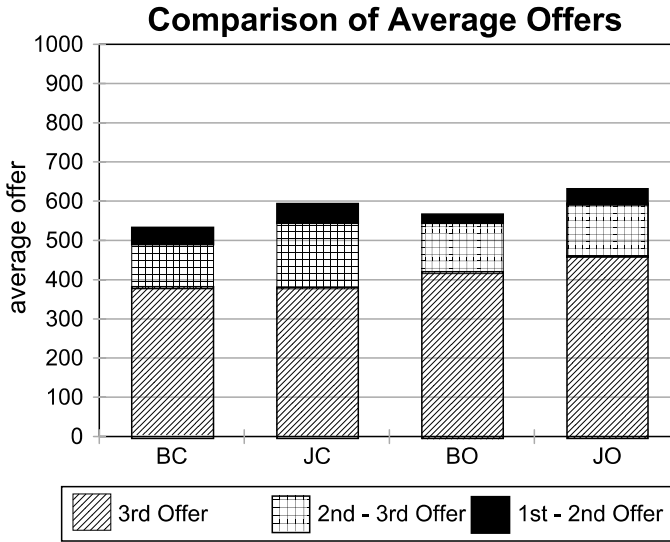


Fig. 3. Comparison of first, second, and third proposer offers.

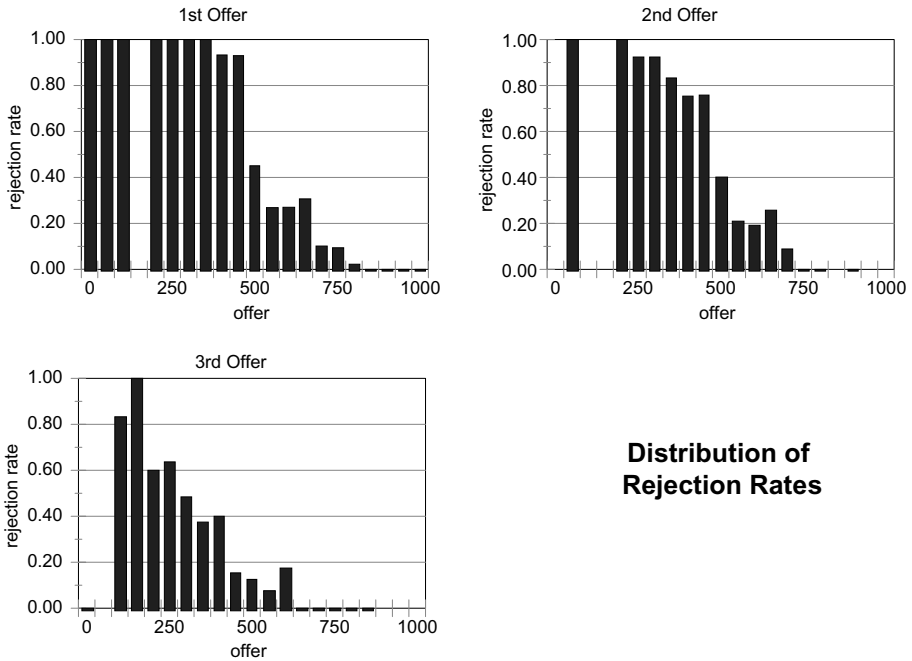


Fig. 4. Distribution of rejection rates.

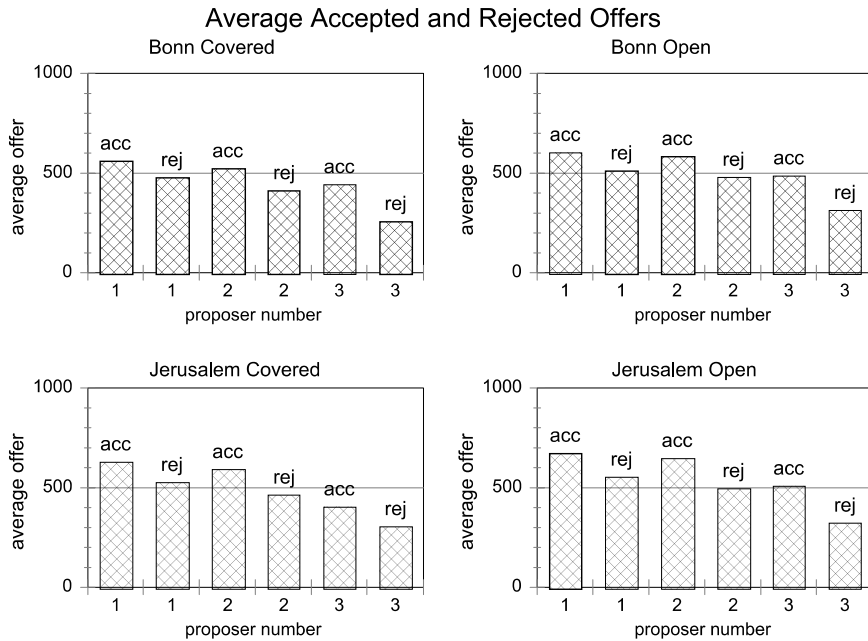


Fig. 5. Average accepted and rejected offers.

but also to the sequence of play: Third proposer offers are rejected less frequently in every range. Yet it is also true for third proposer offers that they are much more frequently rejected when they are below 500 than when they are equal to or above 500.

Average accepted and rejected offers are depicted in Fig. 5. The significantly decreasing sequence of offers, described in the previous section, prevails even if accepted and rejected offers are analyzed separately. Not surprisingly, in each stage accepted offers are higher than rejected offers. Furthermore, rejected offers in stage 1 are lower than the accepted offers in stage 2. Similarly, stage 3 accepted offers are higher than stage 2 rejected offers in three of four cells.

It is noteworthy that the average rejected offer in the first stage is above 502 in three out of four cells and the accepted stage 2 offers are even higher. This is not in line with the fairness utility models because of the following reasons. In the last stage of the game a fairness utility proposer would at maximum offer 500. Thus, in the second stage no offer greater than 501 can be expected by the responders. Hence, the motive for rejecting an offer greater or equal to 502 in the first stage cannot be a higher monetary payoff. According to fairness utility theories this can only be the case if the monetary advantage is sacrificed for greater fairness, i.e. for a lower but less unequal offer. A responder, however, as conceived in the fairness utility models, would not reject a first offer of more than 502 but then accept an even higher and thus more unequal offer in stage 2. Apparently, the competition in our setup has an influence on behavior which is not completely captured in the fairness utility models so far.

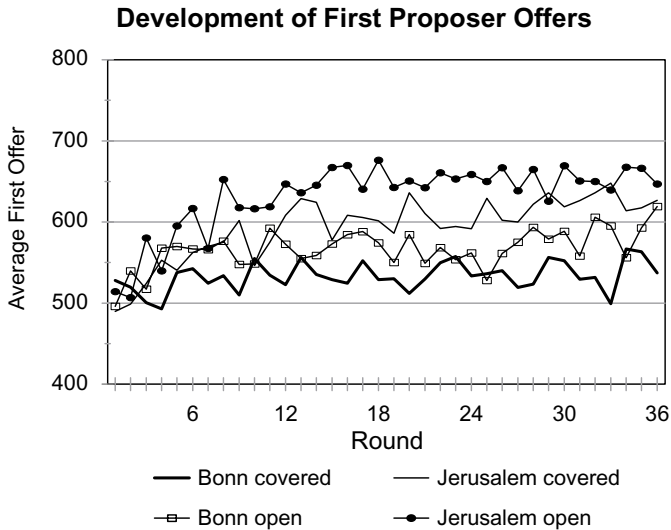


Fig. 6. Development of average first proposer offer.

4.4. The effect of competition over time

In the previous sections, we analyzed averages over all 36 rounds of play and discovered that average offers and average payoffs do not match any of the four benchmarks. In this section, we will examine the question whether there is a clear convergence towards one of the predictions. Fig. 6 shows the evolution of the average first proposer offers.¹¹ The graphs show that in the very early rounds, the average offers are close to the equal split between the first proposer and the responder. Then, they rise quickly until the middle of the experiment. In the second half of the experiment, they seem to stabilize¹² on levels not predicted by any of the four benchmarks.

4.5. Treatment differences

As mentioned above, the first proposer offers are close to 500 in the very early rounds and rising afterwards. However, we can observe that in later rounds, the average first proposer offer is higher in the open treatment than in the covered treatment in both of the two subject pools.

It is interesting that Fig. 6 suggests a tendency to higher first proposer offers by the subjects in Jerusalem than are observed in the Bonn subject pool. In both treat-

¹¹ For the second and third proposer, too few observations are available for a meaningful analysis.

¹² For the first half of the experiment the Spearman rank correlation coefficient between the round number and the average first offer is positive in 21 out of 24 sessions. In 18 of these 21 sessions the second half coefficients are smaller than the first half coefficients.

ments – covered and open – the two-sample randomization test rejects the null hypothesis of equally high average first proposer offers in favor of the hypothesis of higher average first proposer offers in the Jerusalem subject pool at a significance level of at least $\alpha = 0.05$ (one-sided). Thus, the Jerusalem subjects tend to offer the responder more than the Bonn subjects.¹³

5. Summary and conclusions

Cooperative and non-cooperative concepts have always co-existed in economic theory. In the *Fisherman's Game* introduced and analyzed in this paper, four different benchmarks – two cooperative and two non-cooperative ones – make distinct predictions spread over the entire range of possible outcomes. Looking at the data of our experiment, we find that none of the four benchmarks is fully satisfactory. Proposers' behavior is caught in the tension between competition and fairness considerations. Proposers start off with offers around the equal split. Over time, competition drives offers higher, until they stabilize on levels clearly above the equal split, but well below the cooperative benchmarks. Initially, responders' behavior appears to be guided by fairness considerations. Over time, however, responders discover and exploit their powerful position to some extent.

In our setup, the cooperative concepts take proposer competition and responder market power into account. This is reflected in our finding that adding proposer competition to the classical ultimatum game drives offers up, giving responders a larger share on average. In fact, this share is larger than fairness utility can account for. On the other hand, the sequential rationality of the non-cooperative benchmarks also receives some support from our data. As if applying the backward induction reasoning, proposers in earlier stages on average make somewhat higher offers than their successors. Accordingly, responders' reluctance to accept low offers is much more pronounced in earlier stages. Since elements of both cooperative and non-cooperative game theory are crucial for explaining our data, we conclude that effort towards bridging the gap between both approaches is a promising avenue for future research.

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¹³ In recent years, several experimental studies comparing behavior in different countries have been conducted. Brandts, Saijo, and Schram (2000) find virtually no differences between the behavior of subjects in Amsterdam, Tucson, Barcelona, and Tokyo. Lensberg and van der Heiden (2000) find small, but significant differences in the behavior of Dutch and Norwegian students in a gift exchange game. Willinger, Lohmann, and Usunier (2000), find significant differences between German and French students in an investment game, in the sense that Germans show more trust to the second mover than French students.

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Appendix A

A.1. Instructions for the offering game experiment

Player types:

There are two types in the experiment: proposer and responder. After the instruction, each participant draws one of 12 cards. The drawn card defines the terminal number of the participant. The terminal number determines the participant's type for the whole experiment.

Structure:

The experiment consists of 36 rounds. In each round three new groups of participants are formed: each group consists of three proposers and one responder. The proposers in each group are put in an order. This means that there is proposer 1, proposer 2, and proposer 3. The composition of the group changes randomly from round to round. If you are a proposer, in each round you have an equal probability of being proposer 1, 2 or 3.

Decisions:

Each round begins with proposer 1 offering a split of 1000 points into two sums – one for the responder and one for himself.

[The responder is informed about the offer of proposer 1. Nobody else is informed of this offer.]¹⁴

[The other group members are informed about this offer.]¹⁵

The responder has to decide, whether to accept or reject this first offer. If the responder accepts the offer, the points are divided between proposer 1 and the responder according to the offer. Then the round ends.

¹⁴ The text in these brackets was used in the covered treatment.

¹⁵ The text in these brackets was used in the open treatment.

If the responder rejects the first offer, nobody receives any points at this stage.

Now it is proposer 2's turn to offer a split to the responder.

[Again, only the responder is informed of this offer.]¹⁴

[The other group members are informed about this offer.]¹⁵

The responder has to decide, whether to accept or reject the second offer.

If the responder accepts the second offer, the points are divided between proposer 2 and the responder according to the offer. Then the round ends.

If the responder rejects the second offer, nobody receives any points.

Now proposer 3 is asked for an offer.

[Again only the responder is informed of this offer.]¹⁴

[The other group members are informed about this offer.]¹⁵

The responder has to decide, whether to accept or reject the third offer.

If the responder accepts this last offer, the points are divided between proposer 3 and the responder according to the offer. Then the round ends.

If the responder rejects the last offer, nobody receives any points and the round ends.

Exchange rate:

Each 200 points earned in the experiment is equivalent to 1 NIS.

Computer screens:



This is the decision screen for proposer 1. Proposer 1 offers a split between himself and the responder. This is done by typing in the number of points that the responder will get in case he accepts the offer. The rest of the points (out of

1000) will remain for proposer 1 himself. If it is proposer 2's or proposer 3's turn to offer a split, their screens look similar to the above screen, and offers made by proposers before them are [symbolized on the screen by question marks.]¹⁴ [shown in the corresponding fields.]¹⁵



This is the decision screen for the responder. The proposed offer is displayed on the screen. The responder has to decide whether to accept or reject the offer by typing in Yes or No, or by clicking the corresponding mouse button on the screen.



This is the screen for a proposer that has to wait while other participants are making their decisions (here the screen for proposer 2 is shown).

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