The Indirect Evolutionary Approach To Explaining Fair Allocations*

Steffen Huck
Department of Economics
Humboldt University, Berlin

Jörg Oechssler†
Department of Economics
Humboldt University, Berlin

forthcoming *Games and Economic Behavior*

August 13, 1998

Abstract

Experimental results on the ultimatum game show clearly that (1) large fractions of players offer a 'fair' allocation and (2) that unfair (but positive) offers are systematically rejected. We offer an explanation of this behavior using the 'indirect evolutionary approach' which is based on the assumption that players behave rationally for given preferences but that their preferences change through an evolutionary process. We prove that despite anonymous interaction a preference for punishing unfair offers is an evolutionarily successful strategy if players interact in small groups. This leads players to split the resource equally almost always. However, the equal split is not due to 'true fairness' (or 'altruism') but is entirely caused by the (justified) fear that unfair offers might be rejected.

JEL– classification numbers: C73, D 83.

---

*We thank Georg Nöldeke, Karl Schlag, Johan Stennek and seminar participants at Bonn, Copenhagen, Rotterdam and Vienna, as well as participants at a Transcoop workshop in Tuscon, the 1996 Stony Brook conference and the Econometric Society Winter Symposium (Europe) for very helpful comments. Three anonymous referees added valuable comments that helped to improve the paper considerably. Financial support by the Deutsche Forschungsgemeinschaft SFB 373 is gratefully acknowledged.

†Institut für Wirtschaftstheorie, Spandauer Str. 1, 10178 Berlin, Germany,
FAX: +49–30–2093-5619, E–mail: oechsler@wiwi.hu-berlin.de

1 Introduction

Experimental results on the ultimatum game (see for surveys Thaler, 1988 or Roth, 1995) show clearly that (1) large fractions of players offer a 'fair' allocation and (2) that unfair, though positive, offers are systematically rejected. Relying on three former studies[1] Harrison and McCabe (1992) computed overall distributions of offers in terms of percentages and the according rejection rates. They show that 43% of all proposers offered an equal split, while more than 52% of proposals offering less than a quarter of the resource ('cake') were rejected.

These results stand in contrast with the predictions of subgame perfect equilibrium when players are motivated solely by personal monetary gains. One way of explaining this is to modify players utility functions so as to reflect also considerations of 'fairness', 'envy' or similar motives (see e.g. Bolton, 1991 or Kirchsteiger (1994)).[2] However, a natural question to ask is then *why* a person might develop such a preference.

One framework for analyzing the latter question is provided by the so–called 'indirect evolutionary approach', first proposed by Güth and Yaari (1992).[3] It provides an evolutionary foundation for preferences and follows thereby a suggestion first made by Becker (1976). The indirect evolutionary approach is based on the assumption that players behave rationally for given preferences but that their preferences change through an evolutionary process. In particular, we assume that the evolution of certain preference parameters in the population depends on the relative success of individuals endowed with these preferences. While preferences might be inherited literally in a genetical sense, one could also think of it in terms of social evolution since preferences and value judgements of children are shaped by taking parents or peers as role models. In our view, this (indirect) approach fits better the situation encountered in experiments than the usual (direct) evolutionary approach, which operates on strategies rather than preferences.

[1] Güth *et al.* (1982), Prasnikar and Roth (1992) and Forsythe *et al.* (1994).

[2] An alternative explanation for the experimental results is based on reputation effects. However, the same results hold even for one–time and/or anonymous interaction (see Bolton and Zwick, 1995) when reputation effects can be avoided by careful experimental designs.

[3] For an application of this approach to the endowment effect see Huck, Kirchsteiger and Oechssler, 1997.

Evolution of preferences is a very long term process. But our approach is not designed to model learning behavior *during* an experiment. Rather, it is designed to explain why players enter the laboratory with the preferences they have. We do not deny that important learning effects may occur during an experiment. But since first–round behavior cannot be explained by learning, we see the two approaches, evolution of preferences and learning, as complementary to each other.

We model a mini ultimatum game (see also Gale *et al.* 1995, and Bolton and Zwick, 1995), which retains all important strategic features of the full ultimatum game while being considerably simpler to analyze. A mini ultimatum game differs from the ultimatum game by giving the proposers only two options: either offer a 50:50 split or offer ε to the other player and keep the rest. We consider a population in which players are repeatedly matched to play this game, once in the role of proposer and once in the role of responder. There are two types of players. The first type is only interested in his material payoff. The second type is interested additionally in being treated 'fair' (but not in treating others fair). The latter type may take 'revenge' by rejecting grossly unfair offers. It is important to note that the type of player (whether revengeful or not) influences only his behavior as a responder not as a proposer.[4]

The key question is now whether individuals of the revengeful type are evolutionarily successful in the sense that their population share increases. At first this seems unlikely since an individual gives up resources when rejecting unfair offers and receives only subjective utility which does not enter his fitness function. Güth and Yaari (1992) resolve this problem by assuming that players are able to recognize the preferences of their opponents which in our case would, of course, lead all proposers to offer the fair division if they are matched with a revengeful responder. While this assumption might be justified in some cases (see Frank, 1988), we believe that in most cases players will not be able to know their opponent's type, in particular since all responders have an incentive to mimic the revengeful types. Consequently, in Section 2 we will present a model with anonymous interaction (so that reputation effects can play no role) and with incomplete information of players regarding their opponents' types.

In Section 3 we analyze a simple case in which individuals interact with

[4]There is no kind of altruism involved in the model: As Bolton (1991) suggests, players who have a preference for relative money care only for their share; they do not suffer when they themselves get more than half the resource.

everyone in the population. We show that revengeful types are evolutionarily successful and, therefore, fair behavior results in the long run if the population is not too large. The intuition for this result is the following. In terms of the resources lost it is not very costly for a responder to reject egoistic offers for small ε. But the loss for the proposer is substantial. Thus, for any given finite population size there is an ε small enough such that a revengeful type does better than an egoistic type. Under monotone dynamics the revengeful types will then take over.

In Section 4 we relax the restriction on population size by assuming that individuals interact in *groups* rather than with the whole population which seems to be more realistic. Group sizes and compositions may vary over time. In this framework we can prove that vengeful types may be present in the long run regardless of the overall population size. In Section 5 we comment on the distinction between the direct and the indirect evolutionary approach, and Section 6 adds some final remarks.

2 The game

We study the mini ultimatum game shown in Figure 1. The proposer has to suggest how a given resource, which is normalized to size 2, shall be allocated among proposer (P) and responder (R). In order to keep the analysis simple while retaining the main strategic aspects of the full ultimatum game, only two choices are allowed for the proposer. An egoistic split (E) in which he keeps $2-\varepsilon$, where ε is the smallest unit of the resource ($\varepsilon < 1$), and a fair split (F) in which both get 1. The responder can either accept (a) or reject (r) the proposal. If he accepts, the resource is allocated according to the suggestion. If he rejects, both get nothing.

[place fig. 1 about here]

Players derive subjective utility from the allocation of resources. To simplify we assume that utility equals the amount of resource consumed — with one exception: There are two types of players, $j \in \{A, B\}$, Type A is only interested in his absolute share of the resource, i.e. $\rho_A = 0$. Players of type B derive extra utility from rejecting unfair offers, i.e. $\rho_B = \rho$, where ρ is a 'revenge parameter' with $\varepsilon < \rho < 1$.[5] Accordingly, players of type A

[5] Our results do not depend on the exact form of the utility function as long as it is monotonically increasing. We assume linearity only for notational simplicity. The

will accept both possible offers whereas players of type B will only accept an equal split.

Note that there is an important difference between material payoff and subjective utility. While the latter guides the decisions of individuals only the former influences the fitness of an individual. *Fitness is derived only from the consumption of the resource.*[6]

3 A simple case

Consider a finite population of fixed size N and assume that in each period t all individuals play the mini ultimatum game twice in a round robin fashion – once in the role of the proposer and once in the role of the responder. The composition of the population is assumed to be driven by some monotonic evolutionary process where types' growth rates depend positively on their *average material payoff* in this period.

In contrast to Güth and Yaari (1992) we assume that players cannot recognize their opponent's type when being matched. Instead, we assume that players only know the composition of the population at each time. Before they start playing they are assumed to fix a strategy for all encounters.[7] While their behavior when in the role of responders is pre–determined by their type, their behavior as proposers obviously depends on the composition of the population.

Let n_A^t be the number of A–players at time t. Analogously, $n_B^t = N - n_A^t$ denotes the number of B–players. Knowing that A–players accept all offers whereas B–players accept only fair offers (F), the fair offer F is an optimal action for an A–player if

$$(2-\varepsilon)\frac{n_A - 1}{N-1} \leq 1. \tag{1}$$

Otherwise he will choose E. For a B–player the fair offer F is optimal if

$$(2-\varepsilon)\frac{n_A}{N-1} \leq 1. \tag{2}$$

restriction to two types is without loss of generality because it only matters whether a type's ρ is smaller or larger than ε.

[6]The results we shall obtain would go through a fortiori if ρ entered a player's fitness function in some positive way.

[7]We make this assumption to omit Bayesian updating about the composition of the population within a single period. It simplifies the analysis significantly but does not drive the main results.

In case the proposer is indifferent between E and F we assume that he chooses the fair offer. This tie–breaking rule seems reasonable but it would not make any difference to assume the opposite. Using conditions (1) and (2) we can then distinguish three cases:

Case 1 $n_B \geq (1-\varepsilon)n_A + 1$: Both types choose F when in the role of a proposer. The average material payoffs are $\Pi_A^1 = \Pi_B^1 = 1$.

Case 2 $(1-\varepsilon)n_A + 1 > n_B \geq (1-\varepsilon)n_A$: Type A chooses F, type B chooses E. The average material payoffs are $\Pi_A^2 = 1 - \frac{(1-\varepsilon)n_B}{2(N-1)}$ and $\Pi_B^2 = \frac{n_A(3-\varepsilon)}{2(N-1)}$.

Case 3 $(1-\varepsilon)n_A > n_B$: Both types choose E. The average material payoffs are $\Pi_A^3 = \frac{(2-\varepsilon)(n_A-1)}{2(N-1)} + \frac{\varepsilon}{2}$ and $\Pi_B^3 = \frac{(2-\varepsilon)n_A}{2(N-1)}$.

Now suppose that $N < \frac{2}{\varepsilon}$. It is easy to see that in this case $\Pi_B^2 > \Pi_A^2$ and $\Pi_B^3 > \Pi_A^3$. The reason is that a responder who rejects unfair offers inflicts relatively more harm on all unfair proposers than on himself. Therefore, all monotone evolutionary dynamics imply that the proportion of B–players will grow as long as $n_B < (1-\varepsilon)n_A + 1$. This process will finally yield $n_B \geq (1-\varepsilon)n_A + 1$, i.e. some state in which all players choose F and earn the same material payoff.

Result *If $N < \frac{2}{\varepsilon}$, all monotone evolutionary dynamics yield fair behavior in the long run.*

For $N \geq \frac{2}{\varepsilon}$, the outcome of the dynamics depends on the initial state. If the proportion of B–players is large enough initially, there is no selection pressure against them. However, if the proportion of A–players is large initially (case 3), then egoistic behavior will dominate in the long run.

Note that for any given finite N there is an ε such that the condition above is satisfied, and vice versa. But even for non–negligible ε, we will show in the next section that fair behavior can take over. So far the assumption was that individuals interact with everyone in the population. It seems more realistic to assume that players interact only with a subpopulation. In the next section we will therefore introduce a model in which the population is partitioned into groups. This will allow us to state a result which is independent of population size.

4 Populations with group structures

Again we assume that the population is of fixed and finite size N, but now we add the assumption that it is partitioned into various *groups* of players. The number of players in a group may vary over time according to the evolutionary success of its members. Let N_i^t denote the number of players in group i in period t. Let n_{ij}^t denote the number of type–j players in group i in period t, $j \in \{A, B\}$. The *state of the system* is completely specified by a matrix $n^t := (n_{ij}^t)_{i=1,...N, j\in\{A,B\}}$.[8] Let Ω denote the finite state space.

Each player is being matched twice against all other players in his group in a round robin fashion, once in the role of the proposer and once in the role of the responder.[9] Thus, in period t every individual in group i plays the game $2(N_i^t - 1)$ times. Let Π_{ij}^t denote the average material payoff of a type–j player in group i from these matches. An individual who is alone in his group is treated as an 'outcast' without any interaction. His payoff is assumed to be zero.

The assumed group structure makes it necessary to be more precise about the evolutionary dynamics which determines the evolution of preferences in the population. We assume that there are just enough resources to keep the size of the total population fixed. Only the distribution of types and the size of the different groups change. Since all individuals are involved in a fight for the same resources, payoffs of individuals are compared across the entire population.

The dynamics we look at are a composition of an unperturbed process, a mutation process, and a group splitting process. With respect to the unperturbed process we make the straightforward assumption that *types with higher (material) payoffs grow faster than those with lower payoffs.* This monotonicity assumption is frequently used in the literature (see e.g. Friedman, 1991, or Samuelson and Zhang, 1992). We will use a slightly weaker assumption than usual in that we do not constrain the relative growth rates of types with the *same* payoff. Let

$$\widehat{n}_{ij}^t := \begin{cases} \frac{n_{ij}^{t+1} - n_{ij}^t}{n_{ij}^t} & \text{if } n_{ij}^t > 0 \\ 0 & \text{else} \end{cases}$$

[8] We incur no loss in generality by restricting the number of groups to N. Note that typically there will be some empty groups.

[9] As before we assume that players know the composition of their groups. Clearly, this is a demanding assumption. We conjecture that one can weaken it by assuming that players become aware of changes in the population only one period after they have happened.

be the growth rate of type j in group i at time t.

Assumption 1 *The evolutionary process can be described by a Markov process with transition matrix* $P(0) = (p_{nn'}(0))_{n,n' \in \Omega}$ *which satisfies the following condition. Let* $n^t = n$ *and* $n^{t+1} = n'$, $n \neq n'$ *then:*

$$p_{nn'}(0) > 0 \text{ if and only if } \begin{bmatrix} \forall i,j,h,k \quad \Pi_{ij}^t > \Pi_{hk}^t \Rightarrow \widehat{n}_{ij}^t \geq \widehat{n}_{hk}^t \\ \text{and} \\ \exists i,j,h,k \text{ s.t. } \Pi_{ij}^t \neq \Pi_{hk}^t \end{bmatrix}$$

We call $P(0)$ the unperturbed Markov process for reasons that will become clear immediately. Note that Assumption 1 implies that the process reaches an *absorbing state* if the payoffs of all individuals are equal. This seems to be a plausible assumption because evolutionary selection pressure disappears when all individuals receive the same payoff.

Assumption 1 describes two important aspects of evolution, namely selection and replication. We add now the third ingredient to evolution by defining a mutation process, which when taken together with the selection process yields the perturbed Markov process $P(\delta)$, where δ is the mutation rate. Suppose that the characteristics of an individual (i.e. his revenge parameter and his group membership) are inherited by his descendants with probability less than one. With strictly positive probability an individual changes his type and/or group.

Assumption 2 (Mutations) *At the end of each period the characteristics of each individual change with probability* $\lambda_{ij}\delta > 0, \forall i,j,$ *and* $\sum_{ij} \lambda_{ij} = 1, \lambda_{ij} \in (0,1)$, *whereby an individual of type* j' *in group* i' *becomes a* j*-type in group* i.

Note that the exact specification of the weights λ_{ij} in the mutation process is unimportant as long as the mutation process is independent of the state and has full support.

When the members of a group have high fitness for several generations, group size may become quite large. However, in most social contexts groups do not grow without bound. Consider, for example, the case of families. Even though more and more people become related to each other as time progresses, somehow family size has remained constant or has been decreasing over time. Apparently families split up once they reach a certain size. We will assume that there exists a maximal group size, $\bar{N} < N$. Once this maximal group size is reached, the group splits into subgroups.

Assumption 3 *If $N_i^{t+1} \geq \bar{N} > N_i^t$ group i splits up into as many subgroups as required such that no subgroup of i has more than $\bar{N}$ members. Furthermore, if possible, there is at least one individual of each type represented in each subgroup.*

The latter part of the assumption is intended to make sure that the subgroups are not entirely different from the original group. For example, it excludes the case of an original group, which was mixed 50:50, splitting up into one subgroup of only A–types and one subgroups of only B–types.

We can now state the main result of the paper.[10]

Theorem 1 *If $\bar{N} < \frac{2}{\varepsilon}$, then for arbitrary initial conditions the fair offer F will be observed almost always in the long run as $\delta \rightarrow 0$. If $\bar{N} \geq \frac{2}{\varepsilon}$, then two types of groups have positive probability in the limit: Either all group members offer F or all group members are of type A, i.e. they offer E and accept all offers.*

Proof By Proposition 1 of Nöldeke and Samuelson (1993) a state can appear in the support of the stationary distribution of $P(\delta)$ for $\delta \rightarrow 0$ only if it belongs to a 'locally stable component'. A component is a minimal collection of absorbing sets with the property that all absorbing sets are connected via a series of transitions that each require only one mutation. A component is locally stable if it takes at least two mutations to reach any other component (see Nöldeke and Samuelson, 1993). Given Assumption 1 it is straightforward to show that all absorbing sets are singletons. A state is absorbing either if everyone receives the same payoff or if all groups have only one member.

Consider first the case of $\bar{N} < \frac{2}{\varepsilon}$. We will show that every locally stable component consists of states in which in all non–empty groups $n_{iB} \geq (1-\varepsilon)n_A + 1$. We call such states F–states as all proposers will choose F (see case 1 from above). Consider first an absorbing state with a group in which everyone is of type A. From this state one mutation is sufficient to turn the A–group into an F–group because then $\Pi_{iB} > \Pi_{iA}$. On the other hand turning an F–group into an A–group always requires at least two mutations as the following argument shows.

If group i is an F–group, then one mutation would reduce n_{iB} to at most $(1-\varepsilon)n_A$. That is, either the group is still an F–group or $(1-\varepsilon)n_A + 1 >$

[10] The result of the previous section is a special case of Theorem 1 for $N < 2/\varepsilon$, $N \leq \bar{N}$, $\delta = 0$, and initial states n^0 with $n_{ij}^0 = 0$ for all $i \neq 1$.

$n'_{iB} \geq (1-\varepsilon)n_A$, which corresponds to case 2. For the latter case we know that $\Pi_{iB} > \Pi_{iA}$ if $\bar{N} < \frac{2}{\varepsilon}$ and therefore $\widehat{n}_{iB} > \widehat{n}_{iA}$. This in turn implies that the process changes group i back into an F–group. Note also that Assumption 3 guarantees that no pure A–group can result from the splitting process. Therefore, no locally stable component contains states with A–groups. The same argument shows that F–states belong to locally stable components as it always takes at least 2 mutations to reach a non–F–state. States in which all groups consist of a single member do not belong to locally stable components either as one mutation is sufficient to reach another component.

If $\bar{N} \geq \frac{2}{\varepsilon}$, pure A–states can be reached from F–states with one mutation since $\Pi_{iB} \leq \Pi_{iA}$ in cases 2 and 3 if $\bar{N} \geq \frac{2}{\varepsilon}$. Therefore, both types of states belong to a locally stable component and are in the support of the limit distribution as $\delta \to 0$. ■

It is important to see that while the theorem is stated in terms of *behavior* of players, it is based on the evolution of their *preferences.* It is the evolution of the revenge parameter, the evolution of A– and B–types in the population, which matters. The theorem states that almost all proposers will offer the fair split if $\bar{N} < \frac{2}{\varepsilon}$. Note, that this does not imply that all responders are necessarily of the 'revengeful' type B. It is sufficient that the proportion of revengeful types in each group is high enough (roughly a majority of B–types is needed in each group) to make unfair offers unprofitable.

5 On the difference between the direct and the indirect evolutionary approach

The standard approach in evolutionary game theory or biology is the direct approach, in which players (animals) are genetically programmed to behave in a certain way. In the language of game theory each player is endowed with a particular fixed strategy. These strategies are usually of a simple kind, in fact, they are generally assumed to prescribe a simple *action.* In this sense the key difference between the direct and the indirect evolutionary approach is that in the direct approach the player is programmed to use a given action whereas in the indirect approach a player can react rationally to the environment, that is, he can condition his behavior on the state of the system.[11]

[11] Note that this distinction is one of degree rather than of kind as one could always imagine that players in the direct approach are endowed with a fully contingent strategy.

In our framework the direct approach would allow for four possible strategies (assuming that a fair offer is always accepted): Make the fair offer if in the role of the proposer and accept only fair offers when in the role of the responder (FR). Make the fair offer but accept all offers (FA). Make the unfair offer and accept all offers (EA). And finally, make the unfair offer but accept only fair offers (ER). The following symmetric payoff matrix results when two players are matched twice, once in each role.

	FR	FA	EA	ER
FR	2	2	1	1
FA	2	2	$1+\varepsilon$	$1+\varepsilon$
EA	1	$3-\varepsilon$	2	ε
ER	1	$3-\varepsilon$	$2-\varepsilon$	0

It is fairly easy to see that with our dynamics the direct approach produces the opposite result of the indirect approach, namely, that the unfair offer will be observed almost always. Consider an absorbing state in which all players use strategy FR. The fair offer is enforced by the effective threat that unfair offers are rejected. However, a mutant playing strategy FA can enter without being exposed to any selection pressure. As soon as enough mutants have entered, mutants playing strategy EA can enter and they will receive a higher payoff than both other types. Thus, the system can drift away to a state in which all players use strategy EA.

This latter state is stable as it takes at least two mutations to switch one of the groups back to one in which fair offers are being made. One mutant playing strategy ER is required to push the system out of the absorbing state. If the group is small, players of type ER will get a higher payoff than those of type EA. Once the number of the type ER players is sufficiently high, it takes another mutant (playing strategy FR or FA) to reach an absorbing state in which everyone make the fair offer. This is in contrast to the indirect approach where this last mutation is not required.

While this result seems to be in contrast to that of Gale *et al.* (1995), who analyze the behavior of stochastic replicator dynamics, it is not. They find that a fair outcome can be an asymptotic attractor *but only* if the responders are subject to significantly more noise than proposers. Given our Assumption 2 this does not apply. Furthermore, they cannot select one of

The question is, however, whether evolution could produce the required huge variety of genetical programs in any reasonable time span.

the equilibria since the subgame perfect equilibrium remains an asymptotic attractor for all specifications.[12]

6 Final remarks

The main message of this study is that fairness in the ultimatum game can be evolutionarily stable despite the fact that interaction is anonymous and only summary statistics are available. Punishing others is always costly in absolute terms, but it may improve the relative payoff of those who punish, and since evolutionary forces rely on relative payoffs, a preference for punishment may evolve. Once individuals have acquired such preferences, they will behave according to them even in situations in which it might not be advantageous to do so.

We have distinguished two cases. In the first the number of people an individual interacts with is small relative to $1/\varepsilon$ either because the whole population is small or because individuals interact in groups of limited size. For this case we obtained a strong result predicting that fair behavior will be observed almost always in the long run. If it is true that people are evolutionarily molded for life in small groups, then this case should be the more relevant one. Alternatively, one can argue that for every given population size N there is an ε such that this case holds.

The second case is that group size is very large (or that ε is large). For this case we show that in the long run there may exist groups in which everyone plays fair. But there also may be groups in which everyone is maximizing his monetary payoff. This result is similar to the one obtained by Gale *et al.* (1995) who show that the fair outcome in the mini ultimatum game is one of two local attractors provided that the behavior of responders is noisier than that of proposers.

References

[1] BECKER, G. (1976), "Altruism, Egoism, and Genetic Fitness: Economics and Sociobiology", *Journal of Economic Literature*, 14, 817-826.

[2] BOLTON, G.E. (1991), "A Comparative Model of Bargaining: Theory and Evidence", *American Economic Review*, 81, 1096-1136.

[12] See also Cressman and Schlag (1996) who show that the subgame perfect equilibrium is the unique *interior* asymptotically stable set in the mini ultimatum game.

[3] BOLTON, G.E. and ZWICK, R. (1995), "Anonymity versus Punishment in Ultimatum Bargaining", *Games and Economic Behavior*, 10, 95-121.

[4] CRESSMAN, R. and SCHLAG, K. (1996), "The Dynamic (In)Stability of Backward Induction", SFB 303 Discussion Paper No. B-347, University of Bonn.

[5] FORSYTHE, R., HOROWITZ, J.L., SAVIN, N.E., and SEFTON, M. (1994), "Fairness in Simple Bargaining Games", *Games and Economic Behavior*, 6, 347-369.

[6] FRANK, R. (1988), *Passions within Reason – The Strategic Role of the Emotions*, New York: Norton & Co.

[7] FRIEDMAN, D. (1991), "Evolutionary Games in Economics", *Econometrica*, 59, 637-666.

[8] GALE, J., BINMORE, K., and SAMUELSON, L. (1995), "Learning to Be Imperfect", *Games and Economic Behavior*, 8, 56-90.

[9] GÜTH, W., SCHMITTBERGER, R., and SCHWARZE, B. (1982), "An Experimental Analysis of Ultimatum Bargaining", *Journal of Economic Behavior and Organisation*, 3, 376-388.

[10] GÜTH, W. and YAARI, M. (1992), "An Evolutionary Approach to Explain Reciprocal Behavior in a Simple Strategic Game, in: *Explaining Process and Change — Approaches to Evolutionary Economics*, ed. U. Witt, Ann Arbor, 23-34.

[11] HARRISON, G.W. and McCABE, K.A. (1992), "Expectations and Fairness in a Simple Bargaining Experiment", *mimeo*, University of South Carolina.

[12] HUCK, S., KIRCHSTEIGER, G., and OECHSSLER, J. (1997), "Learning to Like What You Have – Explaining the Endowment Effect", Discussion Paper No. 99, Humboldt University, Berlin.

[13] KIRCHSTEIGER, G. (1994), "The Role of Envy in Ultimatum Games", *Journal of Economic Behavior and Organisation*, 25, 373-389.

[14] NÖLDEKE, G. and SAMUELSON, L. (1993), "An Evolutionary Analysis of Backward and Forward Induction", *Games and Economic Behavior*, 5, 425-454.

[15] PRASNIKAR, V. and ROTH, A.E. (1992), "Considerations of Fairness and Strategy: Experimental Data From Sequential Games", *Quarterly Journal of Economics*, 106, 865-888.

[16] ROTH, A.E. (1995), "Bargaining Experiments", in: *Handbook of Experimental Economics*, eds. J. Kagel and A.E. Roth, Princeton: Princeton University Press.

[17] SAMUELSON, L. and ZHANG, J. (1992), "Evolutionary Stability in Asymmetric Games", *Journal of Economic Theory*, 57, 363-391.

[18] THALER, R.H. (1988), "The Ultimatum Game", *Journal of Economic Perspectives*, 2, 195-206.