Social Learning of Efficiency Enhancing Trade With(out) Market Entry Costs - An Experimental Study

Nadine Chlaß* Werner Güth*† Christoph Vanberg*

Abstract

We investigate experimentally whether entry costs have an impact on the evolution of cooperation in a social dilemma game. In particular, subjects repeatedly play the so-called takeover game with anonymous partners randomly drawn from a fixed population of participants. The game represents a social dilemma because selfishly rational players can fail to make efficient trades due to information asymmetries. In order to create a potential for social learning, we provide subjects with feedback about average results in the population. Our interest lies in observing the extent to which cooperative behaviors facilitating trade are adopted. Our main conjecture is that market entry costs inspire more trade. This is only partly confirmed by the data.

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*Max Planck Institute of Economics, Kahlaische Str. 10, 07745 Jena, Germany

†Corresponding author. Phone:+49-3641-686620 Email:gueth@econ.mpg.de

1 Introduction

One of the most basic and wide-spread observations in economic experiments is that subjects *change* their behavior when repeatedly faced with the same situation.[1] For example, in social dilemmas (e.g. PD, VCM) many subjects initially play cooperative strategies that are strictly dominated. When these games are repeated, cooperation declines. These changes appear to reflect the fact that subjects are 'learning.' This may not seem surprising from a common-sense perspective. However, characterizing the underlying learning processes constitutes a significant challenge for theoretical and experimental research (see Camerer, 2003).

There are two (mutually compatible) ways to think about what experimental subjects are learning as they change their behavior. First, practice may be required in order for people to grasp the causal relationships between their own and others' actions and the consequences (payoffs) that result. Similarly, subjects may learn to predict others' behavior and adjust their own action-outcome predictions accordingly. We can refer to both of these as learning *about the consequences of actions*. Second, individual preferences over actions or consequences may themselves depend on the behavior (and / or inferred motivations) of others. When this is the case, subjects may adjust their behavior as they learn *about the other players*.

Either type of learning implies that an individual's inclination to behave in certain ways (such as acting cooperatively) will be affected by the distribution of behaviors in the (sub)population with whom she has interacted and about whom she has received information in the past. In particular, she will be more likely to act cooperatively if she has interacted with cooperative individuals and if she has received information about individuals who have cooperated successfully.

This implies that social learning of cooperation can be affected by two types of mechanisms. The first are mechanisms which *sort* individuals according to their behavioral

[1] Specifically, this occurs even if the experiment follows a (random) strangers design.

dispositions (e.g. cooperative vs. non-cooperative). The second are mechanisms which *inform* individuals about the behavior and successes of other members of a population.

In our experiment, we study how social learning of cooperative behavior is affected when participation in a social interaction requires prior payment of an entry cost. Although such costs are sunk at the time when the interaction takes place, we speculate that there are four reasons why cooperation is more likely to arise and be sustained under this condition.

(1) First, entry costs may induce an endogenous sorting process. In particular, a cooperative disposition may be correlated with an expectation that others are similarly disposed. If this is true, cooperative individuals will be more willing to pay a cost to participate in a positive sum social interaction. We call this the *selection effect* of entry costs.

(2) A related effect is that subjects who incur the entry cost thereby *reveal* that they expect cooperation. This may be interpreted by others as a signal that the interaction partner intends to cooperate, which may prompt a cooperative response. We call this the *forward induction effect* of entry costs(see the more narrowly defined related concept of Kohlberg and Mertens, 1986).

Both of these effects can potentially produce a self-reinforcing learning dynamic: if cooperative people are more likely to enter, more cooperation will be observed post entry, confirming the expectations which motivated the entry decisions in the first place. This may make cooperation more likely when entry costs are imposed. Note that these effects can only arise if entry costs are *voluntarily* incurred rather than exogenously imposed.

(3) Third, we speculate that the payment of entry costs may affect subjects' payoff aspirations. Specifically, the experienced loss may inspire subjects to search for opportunities to regain the costs of entry. This may cause them to focus on the mutual gains of voluntary cooperation. We call this the *aspiration effect* of entry costs.

(4) The final reason why we believe entry costs may affect behavior and social learning is suggested by Prospect Theory (Kahneman and Tversky, 1979). Specifically, when cooperation requires one or more participants in the interaction to incur risks, Prospect Theory predicts that their willingness to take such risks may increase after costs have been incurred. We refer to this as the *risky shift effect*.

The strength of the latter two effects may again depend on whether entry costs are exogenously imposed or voluntarily incurred. However, in this case it is less clear how. On the one hand, one might argue that aspirations and reference points are affected only by things that happen before choices are made. In this case, we would expect the effect to be strongest when costs are exogenously imposed. On the other hand, one might expect that subjects weigh voluntarily incurred costs more strongly and therefore the effect would be larger when entry is voluntary.

In sum, we speculate that there are several reasons why the payment of entry costs may affect social learning dynamics in a way that increases the chance that cooperative behaviors will arise and be sustained. We believe that testing this conjecture is important because mechanisms analogous to the payment of entry costs abound in 'real life' interactions with social dilemma aspects. (For example, in private clubs, or events such as public and private (procurement) auctions where participants are required to make prior investments or pay entry fees.) Understanding whether sunk costs have the conjectured effect is therefore relevant to a wide range of applications.

2 Related Literature

Social Learning, Cooperation, and Entry Costs

To the best of our knowledge, there are not many experimental studies of social learning in the sense addressed here. With few exceptions, existing studies have focused on so-called cascade models, which do not involve *strategic (social)* interaction. Instead, they are focused on how people learn from the behavior of others, e.g. infer from observing others' choices the information they have, in order to make better individual choices (e.g. Anderson and Holt, 1997). Gueth et al. (2006), similar to our study, provide information feedback which can be used as a common prior in Bayesian updating in their evolutionary and experimental analysis of a stochastic game.

Van Huyck, Battalio and Beil (1993, 1991) have shown experimentally that exogenously imposed sunk costs affect behavior in coordination games. They study games with multiple strict equilibria which can be ranked by payoff dominance. After imposing entry costs, participants coordinated on higher-paying equilibria which covered those costs. One might refer to this as a *coordination effect* of sunk costs. Cachon and Camerer (1996) argue that this effect is due to what they call a 'loss avoidance' principle: "Players do not pick strategies that result in certain losses for themselves if other (*equilibrium*) strategies are available" (emphasis added). It is important to point out that our setup does not allow for such coordination effects because the equilibrium benchmark in our framework is always unique. The hypothesis we are testing is whether sunk costs can induce subjects to play cooperative *non-equilibrium* strategy profiles.

More closely related to our approach, Gaechter and Thoeni (2004) conduct an experiment in which individuals are sorted according to the amount they have contributed to a public good. The results show that such a sorting process leads to higher and more sustained cooperation in the high-contributor group. Gaechter and Thoeni speculate that this effect is due to the fact that subjects feel they are interacting with 'like-minded' individuals and *expect* more cooperation from others. [2] This supports our expectation that entry costs may contribute to cooperation through what we refer to as the sorting and forward induction effects.

[2] A complementary interpretation is that subjects in the cooperative group actually *experience* higher levels of cooperation.

The takeover game

We study the problem of cooperation in the context of an asymmetric information bargaining situation. Specifically, we make use of the "takeover game," also referred to as the "Acquiring a Company Task," first studied by Samuelson and Bazerman (1985). In this game, a buyer makes a take-it-or-leave-it offer to a seller of an object. The value of the object is uncertain and known only to the seller. Further, its value to the buyer is always larger than its value to the seller. Both values are linearly related (common value property).

Despite the fact that it is always efficient for the two parties to trade, an inefficiency analogous to the 'lemons' problem (Akerlof, 1970) arises because the seller is informed about the value of the object while the buyer is not. A rational buyer anticipates that the seller's acceptance of a given offer reveals information about the value of the object (i.e. the seller's valuation is lower than the bid). Under certain parameter constellations, this implies that any positive offer will result in expected losses for the buyer. When this is the case, a rational (and risk averse) buyer should offer a bid of zero and no trade should take place.

This game has been the subject of many experimental investigations (Samuelson and Bazerman, 1985; Ball, Bazerman and Carroll, 1991; Grosskopf, Bereby-Meyer and Bazerman, 2006; Selten, Abbink and Cox, 2005; Dittrich et al., 2005). To date, the literature has focused on demonstrating the so-called "winner's curse" phenomenon that appears to arise. Specifically, a robust finding is that buyers consistently overbid because they fail to take into account how the seller's acceptance of an offer depends on the value of the object. Since sellers have often been played by rational robots (such that nobody earned the seller's profit), this cannot be explained by efficiency concerns. This effect is robust to a great variety of experimental setups, and it does not disappear even when buyers are given detailed feedback (including foregone earnings) and the opportunity to gain extensive experience with a variety of parameter constellations. Notice, however, that trade implies gains and losses with positive probability under all parameter constellations. Learning when it is optimal to trade may therefore be difficult and may require more time than usually provided in experiments.

A general pattern appears to be that buyers' bids lie somewhere in between their own and the seller's ex ante expected valuation (Grosskopf, Bereby-Meyer and Bazerman, 2006). This indicates some kind of forward reasoning ('How should we share the expected pie?') rather than the backward induction analysis required for sequential rationality. This type of reasoning can also be interpreted as an attempt to implement voluntary non-equilibrium cooperation (pie sharing).

Our study differs from the previous literature in the following respects:

- We interpret overbidding as cooperation, i.e. as being motivated by efficiency concerns. (As reflected by the fact that we use human rather than robot sellers.)
- We introduce fixed costs to see how they affect the degree to which buyers overbid.
- We endogenize market entry (a) to allow for sorting of participants according to their cooperative inclinations and / or expectations as well as (b) to strengthen the motive of loss avoidance.

Section 3 presents the theoretical model and the benchmark solution. We show that the equilibrium outcome may not be efficient and construct an example of a cooperative (non-equilibrium) "solution" to the dilemma. We briefly discuss the implications of Prospect Theory in our context. Based on the theoretical discussion, we outline our research questions. Section 4 describes the experimental design and section 5 our results. Section 6 concludes.

3 Benchmark solution and research questions

There are two players, a buyer and a seller. The seller has the option to purchase and immediately resell to the buyer a single unit of a good. The good is characterized by its value to the buyer, v, which is ex ante uniformly distributed on the interval $(0, \bar{v})$. The realization of v is revealed to the seller but not the buyer. The seller's purchase price for the good is equal to a fraction $q \in (0, 1)$ of the buyers valuation. Except for the realization of v, all aspects of the game (including the parameter q) are common knowledge.

The sequence of events is as follows. The buyer makes an offer $p \in \Re$ to the seller, who is aware of v. The seller then chooses to accept or reject this offer. If she accepts, the buyer receives a payoff $v - p$ and the seller receives a payoff $p - q \cdot v$. If she rejects, both receive a payoff of zero.

Since the buyer's valuation is always larger than the seller's purchase price, it is always *efficient* for the seller to accept the buyer's offer. (This is true for any price that the buyer may offer because the payment is merely a redistribution.) Due to the presence of information asymmetries, however, the equilibrium solution may yield no trade under certain conditions.

Benchmark solution with risk neutral traders

A self interested seller will accept an offer p whenever it exceeds his purchase price, i.e. if $p \geq q \cdot v$. Knowing this, a rational buyer will anticipate that an offer of p will be accepted only if $v \leq \frac{p}{q}$. Since any offer $p \geq q \cdot \bar{v}$ will be accepted with probability 1, all offers above $q \cdot \bar{v}$ are dominated by $p = q \cdot \bar{v}$. Therefore a rational and self-interested buyer will consider only $p \in [0, q \cdot \bar{v}]$. The expected value of the good conditional on such an offer being accepted is $\frac{p}{2q}$. Therefore a risk neutral buyer's expected payoff from making an offer $p \in [0, q \cdot \bar{v}]$ is equal to $p \cdot (\frac{1}{2q} - 1)$.

For $q < \frac{1}{2}$, this expression is strictly increasing in p and therefore the buyer's optimal strategy is to offer $q \cdot \bar{v}$. This offer will be accepted by the seller and trade will occur with probability 1. Thus, for $q < \frac{1}{2}$, the benchmark solution leads to an efficient outcome. The buyer's expected utility in this equilibrium is $(\frac{1}{2} - q) \cdot \bar{v}$. The seller's expected utility is $\frac{1}{2}q \cdot \bar{v}$.

For $q > \frac{1}{2}$, the buyer's expected payoff is strictly decreasing in p and therefore her optimal strategy is to offer 0. This offer is not accepted by the seller and no trade occurs. That is, for $q > \frac{1}{2}$, the benchmark solution is not efficient, meaning that self interested rational players will fail to maximize their joint payoffs. In this case, both receive a payoff of zero.

In the experiment, we set $\bar{v} = 10$ ECU (Experimental Currency Units) and we use parameters $q = 0.2$ and $q = 0.6$. Thus, our benchmark solution is as follows:

- Sellers accept offers when they exceed the purchase price, i.e. when $p > q \cdot v$.
- For $q = 0.2$, buyers offer $p = 2$ and trade always occurs on the solution paths. Buyers earn on average 3 ECU and sellers earn on average 1 ECU.
- For $q = 0.6$, buyers offer $p = 0$, no trade occurs, and participants earn zero.
- For $q = 0.2$, both risk neutral buyers and sellers pay the market entry costs of 0.5 and 0.05 ECU.
- For $q = 0.6$, both risk neutral buyers and sellers refuse to pay positive market entry costs.

Naive buyer behavior

Sellers, whose decision task is very simple, can reasonably be assumed to behave optimally. Suppose however that the buyer is naive and fails to correctly anticipate the seller's behavior. There are two conceivable behaviors in this case. First, the buyer may simply bid his expected value. In our case, this is as follows:

Naive buyer benchmark 1:

- Buyers bid $p^{naive1} = 5$, irrespective of q.
- Sellers accept whenever $q \cdot v \leq p$.
- Trade occurs with probability 1 when $q = 0.2$ and with probability $\frac{5}{6}$ when $q = 0.6$.
- Buyers' expected earnings conditional on trade are 0 when $q = 0.2$ and $-\frac{5}{6}$ when $q = 0.6$.
- Seller' expected earnings conditional on trade are 4 when $q = 0.2$ and 2.5 when $q = 0.6$.

A slightly more sophisticated buyer may think about the seller's decision, but act as though the seller does not know the value (i.e. purchase price) of the object (see Grosskopf, Bereby-Meyer and Bazerman 2006 for evidence that subjects fail to distinguish symmetric and asymmetric information versions of the game). In this case, the buyer will want to submit a bid equal to the seller's ex ante expected purchase price. This yields the following naive benchmark:

Naive buyer benchmark 2:

- Bid $p^{naive2} = \begin{cases} 1 \quad if \quad q = 0.2, \\ 3 \quad if \quad q = 0.6. \end{cases}$
- Sellers accept whenever $q \cdot v \leq p$.
- Trade occurs with probability $\frac{1}{2}$ irrespective of q.
- Buyers' average earnings conditional on trade are 1.5 when $q = 0.2$ and -0.5 when $q = 0.6$.
- Sellers' average earnings conditional on trade are 0.5 when $q = 0.2$ and 1.5 when $q = 0.6$.

Potential gains from cooperation

The main interest of our experimental analysis is to investigate whether participants can agree on trade and achieve efficient outcomes even when $q > \frac{1}{2}$. To see the potential gains from cooperation, note that if players agree to trade (at any price), their expected joint payoff is equal to $\frac{1-q}{2} \cdot \bar{v}$, which is always positive. In fact, this joint surplus always exceeds even the higher market entry costs we have imposed.

Let's assume that the two players can make a binding agreement to trade at a price $\tilde{p}$ *before* the value of the good is realized. At that point in time, the expected value of the good is equal to $\frac{1}{2} \cdot \bar{v}$. Thus, the buyer receives an expected payoff equal to $\frac{1}{2} \cdot \bar{v} - \tilde{p}$, and the seller receives an expected payoff of $\tilde{p} - \frac{q}{2} \cdot \bar{v}$. Therefore an ex ante agreement to trade at any price $\tilde{p} \in (\frac{q}{2} \cdot \bar{v}, \frac{1}{2} \cdot \bar{v})$ will yield positive expected payoffs for both players. For example, a price $\tilde{p} = \frac{q+1}{4} \cdot \bar{v}$ would yield each an equal expected payoff of $\frac{1-q}{4} \cdot \bar{v}$.

Based on this analysis, we can provide a tentative conjecture about the kind of cooperative strategies that may emerge in the laboratory. Specifically, cooperation might involve buyers making an offer $\tilde{p} = \frac{q+1}{4} \cdot \bar{v}$ and sellers accepting this offer *even when they thereby incur a loss.*

Given our parameters, our *cooperative benchmark* looks as follows:

- For $q = 0.6$, buyers offer $\tilde{p} = 4$ and sellers always accept (even when $.6 \cdot v > 4$).
- Trade always occurs. Both buyers and sellers receive an average payoff of 1. (I.e., exactly half of the expected surplus).

Note that this cooperative scheme is asymmetric in what it requires of buyers and sellers. When they submit offers, buyers expect to make a profit of 1 if the sellers play along. In contrast, sellers are required to knowingly accept certain losses when the purchase price of the good exceeds 4.[3] For example, when $v = 8$, the purchase price for the seller is $0.6 \cdot 8 = 4.8$. Thus, the seller would have to accept a loss of 0.8 in order to grant the buyer a surplus of 4. We will see later that sellers did not behave this way in the experiment.

Of course this is only one of many possible cooperative behavioral schemes we might imagine. More generally, we can define cooperative behavior in this framework as follows:

Definition: *A cooperative strategy profile is a pattern of buyer and seller behavior that involves more trade and therefore yields higher expected aggregate payoffs for all participants in the population than does the benchmark solution.*

According to this definition, cooperative behavior is identified with efficient behavior. A cooperative behavioral scheme must involve trade when the benchmark solution predicts no trade. Though such a strategy will definitely lead to higher aggregate payoffs, it may involve one side of the market making losses for certain parameter values, and regaining those losses for others.

Effects of entry costs under prospect theory

Although the costs of entry are sunk, they may affect subjects' valuation of gains and losses from trade. We discuss the predictions of Prospect Theory in the Appendix. Naturally, these predictions depend on the functional form assumed for the value function. In order to illustrate the possible effects, we use the following evaluation function, varying the loss aversion parameter k from 1 to 2.

$$v(w) = \begin{cases} w^{\frac{1}{2}} & if \quad w \geq 0 \\ -k(-w)^{\frac{1}{2}} & if \quad w < 0 \end{cases}$$

This function exhibits the two central properties proposed by Kahneman and Tversky (1979). First, it is concave in gains and convex in losses, reflecting a diminishing sensitivity

[3] In fact, we know from the equilibrium analysis above that the only way for buyers to attain a positive expected payoff from any positive offer is for sellers to accept it even if it lies below the purchasing price.

to changes relative to a reference point. Second, for $k > 1$, it is steeper in the loss domain than in the gains domain, reflecting a tendency to overvalue losses relative to gains.

The key is that after incurring entry costs, a buyer who evaluates prospects according to this utility function may become risk loving. Since there is a positive probability that he will earn a positive payoff from making an offer even for $q > \frac{1}{2}$, he may be more willing to make such an offer after paying entry costs.

Indeed, we show in the Appendix that, depending on the degree of loss aversion, a small entry cost ($f = 0.05$) can cause the buyer to make a slightly positive offer, and a larger entry cost ($f = 0.5$) may lead him to make a significant offer (between 2 and 4 ECU). Thus, our benchmark predictions under Prospect Theory are as follows:

- For $q = 0.6$, buyers make positive bids when fixed costs are imposed. For small fixed costs ($f = 0.05$), bids are small (less than $\frac{1}{2}$ ECU). For large fixes costs ($f = 0.5$), bids are large (2 to 4.5 ECU).

Research questions

Our main interest is to investigate whether social learning can lead to the emergence of a cooperative strategy profile such as the one suggested above, and to see whether the emergence of such a profile is affected by market entry costs. Thus, the focus of our experimental analysis is on situations in which the benchmark solution derived above predicts that no trade will occur ($q > \frac{1}{2}$).

To observe social learning of cooperation, we let participants interact repeatedly using a random-strangers design.[4] Social learning is inspired by providing feedback information

[4]This design does not change the equilibrium predictions derived above. The same is true for market entry costs, which are sunk. An important effect of repeating the game is that aggregate payoffs will tend to approach expected payoffs. This implies that all players will almost certainly gain if cooperation can be sustained. For example, although the cooperative solution proposed above requires sellers to incur losses in some situations, their long-term aggregated payoff will be positive if cooperation is sustained.

not only on the own bilateral exchange but also on the outcome of all 16 buyer-seller interactions in the previous round (population feedback). Specifically, we provide information about how many of the 16 pairs have actually traded and how much those sellers and buyers earned on average.

We wish to test three hypotheses:

(1) The first hypothesis is that participants adopt cooperative strategy profiles that yield trade even in situations where the benchmark solution predicts no trade.

(2) The second hypothesis is our main conjecture, namely that the imposition of market entry costs will tend to enhance social learning of cooperation.

(3) Our third hypothesis is that the impact of market entry costs depends on whether such costs are exogenously imposed or endogenously accepted by the participants.

4 Experimental Protocol

We ran four sessions with 32 participants each. All sessions were conducted in the experimental laboratory of the Max Planck Institute of Economics in Jena. At the beginning of each session, subjects were randomly assigned to visually isolated terminals where they received a hard copy of the German instructions (see Appendix B. for an English translation). After reading the instructions, participants had to answer a simple control questionnaire (see Appendix C.). Clarifying questions were answered privately at the participant's terminal. The experiment was started after all participants had successfully completed the questionnaire. Instructions for each phase were only given before the phase in question was to start.

In each session, 16 participants were randomly assigned the role of a buyer and 16 participants were assigned the role of a seller. All participants kept their respective role throughout. In each round, subjects were randomly matched to form 16 pairs consisting of one buyer and one seller.

Over the course of the experiment, the same set of subjects experienced different market conditions. The parameters that varied included the value of q, the size of market entry costs (denoted by f), and whether entry was forced (denoted $\delta = 0$) or voluntary (denoted $\delta = 1$). Thus, the treatments in this experiment were within subject.

In phase 1, participants were confronted with the basic takeover game, without entry costs or entry decisions. At the beginning of each round, buyer participants were informed about the current value of q and decided on a bid. After learning the buyer's bid and the randomly selected v, sellers chose to accept or reject the buyer's offer.

At the end of each round, participants were informed about the payoffs resulting from their own interaction. In addition, subjects learned how many of the 16 pairs actually traded and what those who did earned on average (separately for buyers and sellers). This information was provided at the end of each round throughout all of the subsequent phases as well.

Phase 1 was designed to provide information on how participants react to changes in the parameter q. Thus, participants were faced with both markets in which the benchmark solution predicted trade and markets in which it predicted no trade. Specifically, the parameter q alternated between $q = 0.2$ (for two rounds) and $q = 0.6$ (again, for two rounds). This cycle of four rounds was repeated four times, for a total of 16 rounds in Phase 1.

In phase 2, market entry was associated with a cost, but subjects were not permitted to make entry decisions. That is, subjects were *forced* to pay the same commonly known entry costs of 0.5, resp. 0.05 ECU in odd, resp. even rounds. At the beginning of each round, participants were informed that both subjects had paid these costs. In all other respects the rules in phase 2 were the same as in phase 1. Phase 2 was designed to investigate the effects of these exogenously imposed entry costs on behavior. Since the number of treatment conditions increased by a factor of 2, the four round cycle from phase 1 was now repeated 8 times, for a total of 32 rounds in phase 2.

Phase 3 was designed to investigate the specific effects of voluntary (rather than forced) market entry. Participants were faced with the same sequence of parameter constellations as in phase 2. However, they now had a choice of whether to incur the entry costs and participate in the interaction, or to refuse and earn zero for that round.[5] In addition to the information provided at the end of each previous round, subjects now learned how many buyer and seller participants had entered the market (see the added instructions for phase 3 in Appendix B.). Note that entry decisions were made *before* the buyer's bid and before the sellers learned the realization of v. Phase 3 lasted 32 rounds.

Participants were 128 undergraduates at the Friedrich-Schiller University in Jena, Germany, 66 of whom females and 62 males. Considering the specific stochastic nature of our experiment, we randomly recruited subjects from areas providing some training in probability calculus. Table 0 provides an overview over subjects' fields of study.

Economics	Life Sciences	Natural Sciences	Informatics	Others
48	32	21	12	15

Table 0: Nr. of participants according to fields of study

Subjects were recruited using the online recruiting system Orsee developed by Greiner (2004). The software was developed with the help of z-tree (Fischbacher 1999). A session lasted, on average, 134 minutes (minimum: 105, maximum: 150). Average earnings were €14.40 Euros for buyers and €13.60 for sellers (minimum: €1.40 Euros for buyers, €8 for sellers, maximum: €26.80 for buyers, €23.00 for sellers).

[5] Note that the actual number of buyers and sellers could potentially be unequal under these conditions. When this happened, we formed as many trader pairs as possible by randomly selecting the correct number of participants from the 'larger' side of the market and matching them with the 'smaller' side. 'Extra' participants were informed that there was an insufficient number of entrants to enable them to trade. These participants did not incur entry costs.

5 Results

Descriptive Data Analysis

Let us first give a general impression of market interactions. While sellers accepted any offer yielding positive payoffs, buyers adjusted their behaviour to market settings. Average prices and their standard deviations for all settings are shown below. For phase 3, all information in this section is given conditional on market entry. The descriptives below serve illustrative purposes only, as neither averages nor sample deviations display consistency properties here.

		ø bid (σ)	
		q=0.2	q=0.6
phase 1		2.36 (1.04)	3.05 (1.14)
phase 2	$f = 0.05$	2.02 (0.63)	2.52 (1.23)
	$f = 0.5$	2.09 (0.69)	2.45 (1.22)
phase 3	$f = 0.05$	2.00 (0.59)	2.61 (0.91)
	$f = 0.5$	2.17 (0.52)	2.91 (1.29)

Table 1: averages and standard deviations of bids

Throughout the experiment, the average bid for $q = 0.2$ was lower than for $q = 0.6$. In addition, the standard deviation of bids turned out decidedly larger for $q = 0.6$ than for $q = 0.2$. Regarding imposed entry costs (phase 2) neither averages nor standard deviations vary consistently. For voluntarily accepted entry costs (phase 3) the average bid is higher in settings with entry costs of $f = 0.5$ ECU than for $f = 0.05$ ECU.

Table 2 describes the average earnings (and their standard deviation in brackets) by distinguishing $q = 0.2$ and $q = 0.6$, buyers, sellers and phases. In phases 2 and 3, we did not subtract market entry costs to render earnings more comparable. The table also displays the relative frequency of trade for $q = 0.2$ and $q = 0.6$ and the three phases.

	role	q	phase 1	phase 2	phase 3
average earnings conditional on trade	b	0.2	1.90(2.79)	2.37(2.65)	2.51(2.78)
		0.6	-0.59(1.82)	-0.51 (1.60)	-0.49 (1.61)
	s	0.2	1.63 (1.11)	1.27 (0.74)	1.24 (0.70)
		0.6	1.76 (1.24)	1.53(1.12)	1.60 (1.13)
average share of pairs trading		0.2	0.85	0.82	0.87
		0.6	0.48	0.39	0.40

Table 2: average earnings of buyers and sellers split according to phases.

Observation 1. Whereas the gains from trade for $q = 0.2$ considerably increase for buyer participants throughout phases, they slightly decrease for seller participants. Buyers' average gains exceed those of sellers for markets with $q = 0.2$ and do so increasingly. In case of $q = 0.6$ buyers experience losses while sellers' average payoffs are positive without any clearcut temporal trends.

Interestingly, for phases 2 and 3, buyers' losses for $q = 0.6$ seem rather moderate compared to their gains on markets with $q = 0.2$. More specifically, buyers' losses for $q = 0.6$ are, on average, more than compensated by their payoff advantage (compared to sellers) on $q = 0.2$ markets. Contrary to the benchmark solution, the frequency of trade for $q = 0.6$ is significantly positive, albeit decreasing for the latter two phases. For all three phases, however, trade frequency for $q = 0.6$ persists at much lower level than the trading quota for $q = 0.2$. Participants systematically try to exploit the gains from trade even if trade is questioned by opportunism or when engaging in trade is costly. Buyers' gains vary considerably more than sellers', but gain dispersion diminuishes during the two latter phases.

In order to provide an impression of the possible learning dynamics and their directions, table 3 additionally splits the data of each phase into the first half of experiences with each market type (experiences 1 to 4 for phase 1, experiences 1 to 8 for phases 2 and 3) and the second half, (experiences 5 to 8 in phase 1, experiences 9 to 16 in phase 2 and 3) to provide some hints on the possible learning dynamics and their directions.

	role	q	phase 1		phase 2		phase 3	
average earnings conditional on trade	b	0.2	1.62 (2.82)	2.12 (2.76)	2.41 (2.64)	2.34 (2.66)	2.60 (2.78)	2.4 (2.79)
		0.6	-0.59 (1.94)	-0.6 (1.69)	-0.53 (1.58)	-0.49 (1.63)	-0.48 (1.53)	-0.74 (1.72)
	s	0.2	1.90 (1.19)	1.59 (0.97)	1.30 (0.78)	1.25 (0.69)	1.22 (0.71)	1.25 (0.70)
		0.6	1.86 (1.32)	1.65 (1.15)	1.57 (1.09)	1.48 (1.16)	1.53 (1.07)	1.75 (1.22)
avg. share of pairs trading		0.2	0.89	0.80	0.81	0.84	0.85	0.86
		0.6	0.50	0.46	0.43	0.35	0.41	0.37

Table 3: average earnings of buyers and sellers split according to market types and time.

Observation 2. Major earning adjustments occur for $q = 0.2$ during phase 1, with buyer (seller) participants earning considerably more (less) in the second half. Dispersion of gains decreases decidedly. Another noteworthy phenomenon is that trade occurs less frequently in the second part of each phase when $q = 0.6$ applies. This may reflect that participants are learning.

The relative frequency of (no) trade for phases 2 and 3 has so far been averaged over low and high entry cost markets. In Table 4, we list the frequencies of not trading in more detail than in Table 2 and 3. We display frequencies of not trading, that is, efficiency losses, for the 1st, 4th, and 8th experience with each market type.

q		0.2						0.6					
entry costs		0.05			0.5			0.05			0.5		
experiences		1	4	8	1	4	8	1	4	8	1	4	8
phase	1	.06	.14	.17	.06	.14	.17	.39	.52	.59	.39	.52	.59
	2	.22	.19	.11	.20	.17	.12	.55	.61	.67	.56	.61	.72
	3	.16	.06	.15	.20	.06	.08	.55	.48	.71	.5	.48	.57

Table 4: relative share of pairs not trading, split according to market types and time.

Observation 3. In phase 1, learning not to trade can be observed for $q = 0.2$ revealing some haggling on the terms of trade and more considerably for $q = 0.6$. The effects of high and low entry costs on both level and dynamics of the relative no-trade-frequency are surprisingly ambiguous. However, in markets with voluntarily accepted high entry costs (phase 3), efficiency losses are constantly smaller than in those with imposed market entry costs (phase 2).

To measure possibly evolving cooperation we can identify sellers' cooperativeness with accepting a bid below the purchase price. Accepting such a bid implies losses for the seller and gains for the buyer.

A possible measure of buyer cooperativeness provides the difference

$$\Delta_{p|\bar{q}} = p|\{q = 0.6\} - p|\{q = 0.2\}$$

If $\Delta_{p|\bar{q}}$ is positive, buyer offer sellers better terms when their evaluation of the good increases. We interpret this as an attempt to induce trade, and therefore, cooperation. Proceeding similarly for market entry costs f in imposed ($\delta = 0$) and voluntary ($\delta = 1$) settings we define

$$\Delta_{p|\bar{f},q,\delta} = p|\{q, \delta, f = 0.5\} - p|\{q, \delta, f = 0.05\}$$

Here, any positive difference would reflect a bid enhancement to compensate sellers for their entry costs. Again, such a buyer behaviour is interpreted as an attempt to maintain trade, even if costly.

According to the definitions above, we do not find any evidence for cooperativeness on the sellers' side. We observe, however, cooperative behaviour on the buyers' side. For the above stated differences in conditional bids (prices), $\Delta_{p|\bar{f},q,\delta}$ and $\Delta_{p|\bar{q}}$, are derived for each subject and closest following rounds. Each individual distribution of differences is characterized by four location parameters. For the resulting four samples, each containing a particular location parameter of each individual, it is tested whether they are significantly positive (one-sided Wilcoxon tests).

effect	$\mathbf{\Delta_{p\|\bar{q}}}$	$\Delta_{p\|\bar{f},q=0.2}$	$\Delta_{p\|\bar{f},q=0.6}$	$\mathbf{\Delta_{p\|\bar{f},q}}$	$\Delta_{p\|\bar{f},q=0.2,\delta=1}$	$\Delta_{p\|\bar{f},q=0.6,\delta=1}$	$\mathbf{\Delta_{p\|\bar{f},q,\delta=1}}$
expected value	**0.70*****	0.07***	-0.05	**0.004**	0.03	0.05	**0.10****
0.25 quantile	**0.88*****	-0.06	-0.38	$\mathbf{-0.19}$	0.10*	0.26***	**0.19****
0.5 quantile	**0.81*****	0.08***	-0.03	**0.03****	0.02	0.05	**0.08*****
0.75 quantile	**0.83*****	0.22***	0.24	**0.23*****	-0.01	-0.16	**0.01**

Table 5: Investigated characterizations of bid difference distributions.[4,5]

Table 5 displays our estimates of buyers' cooperativeness for all parameter constellations (market settings) and, in bold text, the overall marginal distributions. Each variation in bids is characterized by expected values, 0.25 quantile, 0.5 quantile, and 0.75 quantile, reflecting lower, middle and upper range in bid reaction to illustrate heterogeneity. Let us discuss the results in more detail.

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[4] {*} indicates 0.1 significance levels, {**} 0.05 significance levels, and {***} 0.01 significance levels.

[5] {*} where δ, the parameter indicating voluntary ($\delta = 1$) or imposed ($\delta = 0$) entry is not part of the condition, results stem from phase 2 where market entry was imposed.

Treatment Effects

The experiment allows us to perform within-subject comparisons for three treatment variables, each of them corresponding to a phase. Following the experimental design, we start with phase one, the only treatment here being ***sellers' evaluation parameter* q**. As shown in table 5, participants respond to an increase in q by significantly raising bids. The size of this effect $\mathbf{\Delta_{p|\bar{q}}}$ varies between [0.7; 0.88]. Buyer participants therefore increase the probability of a bid acceptance in markets with $q = 0.6$.

Regarding the temporal development of the effect, the impact of experience (in times a market type has been encountered so far) on the initially negative lower quartiles of $\Delta_{p|\bar{q}}$ ranges between [0.05; 0.12][6](see appendices D.2). However, regressing $\Delta_{p|\bar{q}}$ on buyers' earnings in previous markets with $q = 0.2$ renders the impact of experience itself insignificant. Furthermore, these earnings provide a better explanation of the temporal development mentioned above, whereas actual outcomes with $q = 0.6$ display no impact whatsoever. The increase in lower quartiles is mirrored by an increase in upper quartiles by [0;0.05] with accruing experience. Thus, the overall effect is likely to gain in importance, such trade enhancement of buyers by higher bids being very likely inspired by their earnings in $q = 0.2$ markets.

We now turn to phase two with ***market entry costs f*** occurring for the different market types introduced in phase 1. While on average, bid reactions $\mathbf{\Delta}_{p|\bar{f},q=0.2}$ are significantly positive for markets with $q = 0.2$, a closer look reveals heterogeneity in behaviour. The effect for the 0.25 quantile turns out significantly negative while significantly positive for both 0.5 and 0.75 quantiles. Market entry costs therefore seem to influence bids in different ways. Most buyers repeatedly try to increase the probability of acceptance by making higher bids in case of higher entry costs.

[6] The interval is defined by the smallest and the largest impact of time on the effect in question over all four sessions; when this impact is nonlinear, it is linearly approximated in the text, but see appendices for the actual nonlinear impact

However, regressing the effect on time reveals bid reductions to be only a temporary phenomenon. As captured by the 0.25 quantile, they either do not occur (session 1), or disappear by [0.01;0.03] (see appendix D.3.3.2). We therefore conclude that in the presence of market entry costs, if interactions on markets are frequently expected and experienced as beneficial, buyers tend to offer higher prices to promote the chances of trade.

In markets with $q = 0.6$, reactions on average, 0.25 and 0.5 quantiles remain significantly negative, with only a small subsample of bid enhancements as captured by the 0.75 quantile. However, bid reductions do not show temporal persistence. But once (see appendix D.3.3.4) bid reductions converge to zero by [0;0.11]. Therefore, either entry cost effects will disappear entirely after a while, or eventually reach a moderate positive level as the upper quartiles show persistence.

Let us turn to phase 3. When ***comparing imposed to voluntary market entry*** $\boldsymbol{\Delta_{p|\bar{f},q,\delta=1}}$ in table 5, a significant positive difference of the overall entry cost effects is observed within [0.08; 0.19] over the whole bid reaction distribution, except for the 0.75 quantile. Thus, buyers having already substantially enhanced their bids to compensate sellers for their market entry costs do not enhance it furthermore after voluntary market entry.

The temporal development of $\Delta_{p|\bar{f},q,\delta}$ indeed confirms these static results by frequently displaying significant changes in slope when switching from imposed (phase 2) to voluntary (phase 3) entry (see appendix D.4). Feedback displays a stabilizing impact on this effect: a survival analysis (see appendix D.5) on the determinants of market entry discloses reported positive gains from previous rounds to trigger market entry.This holds regardless of the actual profitability of the market. Entry costs did not affect the entry decision; an increase in q discouraged entry. We therefore conclude that population feedback may to a certain extent stabilize the market entry cost effect in voluntary settings. It is, however, not used by both parties involved.

6 Conclusion

We conducted an experiment to shed light on the effects of entry costs on social learning of cooperation in a social dilemma situation. Our main conjecture was that the imposition of market entry costs along with the provision of population-level feedback would enhance social learning of cooperative behavior.

The emergence of cooperation in social dilemma situations is a wide-spread but ill understood phenomenon (see Ostrom 1990 for related field studies). Existing experimental studies of cooperation have typically focused on complete-information games with rather neutral frames. In order to provide a 'hard' test of our conjecture, we confronted participants with a more complex interaction framed as a market exchange.[6] Unlike social dilemma experiments with complete information, which allow for easy payoff comparisons , the take-over game with its random component renders payoff comparisons more difficult.

The experiment was designed to explore how voluntary cooperation is affected by

- the profitability of trade (there is more trade when it is more profitable)
- market entry costs (the effect of low and high entry costs is surprisingly ambiguous)
- voluntariness of market entry (which induces more trade)
- population feedback (high average last gains from trade inspire market entry, mainly of buyer participants).

Regarding the dynamics, specifically the diffusion of cooperation (i.e. efficient trade), we observe that

[6] Market exchange frames are typically associated with lower levels of 'fairness' concerns and therefore provides an environment in which cooperation is less likely to evolve, ceteris paribus. (See, e.g. Hoffman et al. 1994)

- buyers sustain trade in less profitable markets by drawing on gains in more profitable markets.
- market entry costs persistently and increasingly promote cooperation in beneficial markets.
- voluntary entry strengthens this market entry cost effect
- market entry is encouraged by positive population feedback concerning previous markets (even when the profitability differs).

There is some support for our main hypotheses that social learning enhances trade and that voluntarily paid entry costs inspire attempts to recapture such costs by engaging in trade. But, as might have been expected in the context of a stochastic scenario with privately informed traders, individual inclinations and reactions to own success and population feedback vary substantially.

To observe voluntary cooperation in this more complex but also more realistic situations is by no means obvious. According to our findings there are systematic attempts, mainly of buyer participants, to exploit the gains from trade. Buyers however, often fail since seller participants do not even accept minor own losses for the sake of what can be gained collectively. We conclude that the experimental results provide only weak support for out main conjecture.

Appendix

A. Prospect Theory

We demonstrate how prospect theory affects the predictions of the equilibrium benchmark solution. We focus on a particular, tractable case. We assume that the buyer separately evaluates each choice (i.e. each round) according to the value function

$$v(w) = \begin{cases} w^{\frac{1}{2}} & if \quad w \geq 0 \\ -k(-w)^{\frac{1}{2}} & if \quad w < 0 \end{cases}$$

with $k \geq 1$.

The seller faces no risk and therefore his behavior does not depend on the shape of his valuation function. As long as he prefers more money to less, his strategy will be to accept only when $p > q \cdot v$.

Suppose first that the buyer has not paid an entry cost so that his reference point is zero. Then his expected utility from an offer of $p \in [0, q \cdot \bar{v}]$ is equal to

$$\int_p^{\frac{p}{q}} \frac{1}{\bar{v}}(v-p)^{\frac{1}{2}}\, dv - k\int_0^p \frac{1}{\bar{v}}(p-v)^{\frac{1}{2}}\, dv$$

The derivative of this expression with respect to p is equal to $\frac{p}{\bar{v}} \cdot \left[\left(\frac{1-q}{q}\right)^2 - k\right]$. For $p \in (0, q \cdot \bar{v}]$, this expression is positive if $q < \left(1+\sqrt{k}\right)^{-1}$. Otherwise, it is negative. It follows that if $q \leq \frac{1}{1+\sqrt{k}}$, the buyer will offer $q \cdot \bar{v}$ and the seller will accept. If $q > \frac{1}{1+\sqrt{k}}$, the buyer will offer zero and the seller will reject.

Recall that when the buyer is risk neutral, trade occurs whenever $q < \frac{1}{2}$. Thus, when there is no loss aversion ($k = 1$), the solution is the same under prospect theory. When there is loss aversion ($k > 1$), the maximum q for which trade occurs is smaller. Thus, prospect theory predicts a lower probability of trade in the absence of entry costs.

We now turn to the question of how entry costs affect the buyer's bid. Assume that the buyer separately evaluates the outcome of each round, including the entry cost, denoted by f. For bids $p \in [0, q \cdot \bar{v}]$, the probability that the bid will be rejected is $(1 - \frac{p}{q \cdot \bar{v}})$. In this case, the buyer incurs a loss of f. If $v < \min\{\frac{p}{q}, p+f\}$, the bid is accepted and he incurs a loss of $f+p-v$. If $v \in [p+f, \frac{p}{q}]$, the bid is accepted and he makes a gain equal to $v-p-f$. Note that this occurs with positive probability only if $p+f < \frac{p}{q}$, i.e., $p > \frac{fq}{1-q}$.

Thus, for $p \in [0, \min \frac{fq}{1-q}, q \cdot \bar{v}]$ the buyer's expected utility is equal to

$$\left(1 - \frac{p}{q \cdot \bar{v}}\right) \cdot \left(-kf^{\frac{1}{2}}\right) - \int_0^{\frac{p}{q}} \frac{1}{\bar{v}} k \left(f + p - v\right)^{\frac{1}{2}} dv$$

and for $p \in [\frac{fq}{1-q}, q \cdot \bar{v}]$ (which is nonempty only for $f < (1-q) \cdot \bar{v}$) his expected utility is

$$\left(1 - \frac{p}{q \cdot \bar{v}}\right) \cdot \left(-kf^{\frac{1}{2}}\right) - \int_0^{p+f} \frac{1}{\bar{v}} k \left(f + p - v\right)^{\frac{1}{2}} dv + \int_{p+f}^{\frac{p}{q}} \frac{1}{\bar{v}} (v - p - f)^{\frac{1}{2}} dv$$

An analytical solution to the buyer's maximization problem is difficult. We therefore maximize this function numerically for the parameter constellations used in the experiment. Table X shows the corresponding optimal bids for the buyer.

As the table shows, prospect theory appears to predict an impact of entry costs only if the loss aversion parameter is not too large. Intuitively, a large loss aversion parameter causes the buyer to be risk averse, i.e. his utility function will be concave in the area around his reference point.

Table X: Predicted bids under Prospect Theory

		$f = 0$	$f = 0.05$	$f = 0.5$
$q = 0.2$	$k = 1$	2	2	2
	$k = 1.5$	2	2	2
	$k = 2$	2	2	2
$q = 0.6$	$k = 1$	0	0.5	4.5
	$k = 1.5$	0	0.2	2
	$k = 2$	0	0	0

B. Translation of Instructions

Instructions in the experiment were written in German. The following chapter reproduces a translation into English. Text written in this font marks comments which were not *included in the instructions but are important for this chapter. All other emphases like, e.g. bold font are taken from the original text. Instructions were identical for all subjects.*

Instructions

Welcome and thank you very much for participating in this experiment. Please read the following instructions carefully. Instructions are identical for all participants. Communication with other participants is to cease from now on. Please switch off your mobile phone.

If you have questions, please raise your arm - we are going to answer them individually at your seat.

During the experiment all amounts will be indicated in ECU (Experimental Currency Units). The sum of your payoffs generated throughout all rounds will be disbursed to you in cash at the end of the experiment according to the exchange rate: 1 ECU=0.15 Euros. As negative payoffs through single rounds are possible, you are endowed with 15 ECU. Payoffs achieved during the experiment will be added to this amount. (An eventually negative overall payoff has to be compensated through working at the institute. The hourly wage in this case is set at 10 Euros.)

Information regarding the experiment

The experiment consists of several rounds. In each round, participants are randomly matched to pairs. Within each round you therefore interact with a different participant unknown to you.

Both participants take on different roles. Your role is randomly determined at the beginning of the experiment and remains the same throughout all rounds of the experiment. The role you are assigned to will be communicated at the beginning of the first round.

During each round, participants make decisions. Via their decisions, participants affect both the own as well as the other participant s payoffs. This takes place according to the following rules:

On a market, a potential **seller**and a potential **buyer** of a good meet.The quality of the good is expressed by a number between 0 and 10, randomly drawn at the beginning of each round. 0 indicates low, 10 high quality. Each quality between 0 and 10 occurs with the same probability. The potential seller knows the quality of the good in question, while the potential buyer does not.

First, the potential buyer names an **offer g** between 0 and 10 ECU in order to acquire the good. The potential seller is informed of the offer and decides whether to **accept** or **refute**.

Payoffs of both participants are calculated as follows:

If a seller accepts the offer, trade occurs. In this case, the seller pays a purchase price of $a * q$ ECU and receives the buyer's offer g as price. The seller's payoff in this round therefore is $g - a * q$ ECU, where a¡1. The buyer on the other hand receives in this case the difference between the actual quality of the acquired good and the price payed for the acquisition. That is, he receives $(g - q)$ ECU. If the seller refuses, trade does not occur.

In this case, both participants receive a payoff of 0 ECU. The purchase price payed by the seller always constitutes a fraction q of the actual quality of the good. This fraction q is known to both participants. For two succeeding rounds q is continuedly fixed at 0.2, afterwards at 0.6 and so forth. (Do not worry - in the beginning of each round the actual value for q is once again going to be indicated.)

<u>*Indication*</u>: As fraction q of the good's quality always takes values below One, the monetary value of the good for the potential buyer is always higher than the purchase price for the seller.

<u>*Example*</u>: We are in round 2, and therefore $q = 0.2$. The computer chooses a quality of $q = 0.6$. The potential buyer makes an offer of $5ECU$. If the seller accepts, she pays a purchase price of $0.2 * 6ECU$ and receives the offer of $5ECU$. His payoff thus amounts to:$-(0.2 * 6ECU) + 5ECU = 3.80ECU$. The buyer receives the difference between the

quality, $6ECU$, and her offer, $5ECU$. Consequently, her payoff is $(6ECU - 5ECU) = 1ECU$. If the seller refuses, both participants receive a payoff of $0ECU$.

At the end of each round you are informed about the number of pairs trading. You equally learn your own payoff as well as the average payoff of trading participants in this round.

Your overall income (sum of the endowment and all generated payoffs) appear at the beginning of each round).

We beg for your patience until the experiment starts. Please keep quiet. If you still have any questions please raise your arm now.

Before the beginning of the experiment we would like you to answer some questions.

Information concerning each phase was given directly before each phase. Subjects did neither know of there being different phases nor the number of rounds a phase lasted as we wanted to avoid end game effects.

Phase 2

From now on, every participant has to pay a market entry fee in each round.

The entry fee amounts to 0.5 in odd, and to 0.05 in even rounds. (The entry fee is going to be indicated at the beginning of each round. It is the same for all participants.)

You do not dispose of the option not to pay the entry fee. It is going to be subtracted automatically from your current overall income.

All participants maintain their roles as potential sellers or buyers. As in the previous phase, pairs are generated randomly in each round. After subtraction of entry fees from your current overall income, the steps of phase One follow.

Phase 3

Again, a **market entry fee** has to be paid in the beginning of each round. However, now you are **free to decide whether to pay it and participate in the market or rather abstain from it.**

Continuedly, the entry fee amounts to 0.5 in odd and to 0.05 in even rounds. (The entry fee is indicated at the beginning of each round. Again, it is the same for all participants.)

If a participant decides to pay the entry fee, it is going to be subtracted from his current income at the beginning of each round.

As in this phase, the possibility of an unequal number of sellers and buyers exists, eventually not all participants can be attributed to a pair. They are compensated for the entry fee.

For all participants having paid the entry fee a round follows as previously.

All those having not paid the entry fee and having abstained from the market do not receive any payoff.

Besides the hitherto provided information, all participants now additionally learn at the end of each round how many buyers and sellers have entered the market.

Before the beginning of the experiment each participant had to answer a series of control questions. The experiment started only after all participants had provided the correct answers.

C. Translation of Control Questions

Control Questions

Consider a to be 0.6 and the quality of the good to be 5 ECU, that is, the seller has paid a purchase price of 3 ECU. The offer of the buyer is 4.

1. What is the seller's payoff, if he accepts the offer?

2. What is the buyer's payoff in this case?

3. What payoff does the seller receive if he does not accept the offer?

4. What payoff does the buyer receive in this case?

D. Data

D.1 Temporal development of $q_\alpha(\Delta_{p|\bar{q}}) = \{p|q = 0.6\} - \{p|q = 0.2\}$

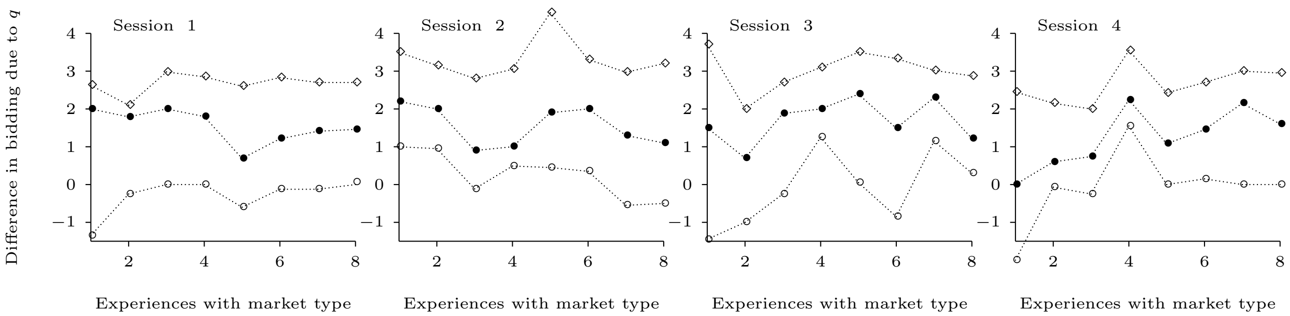

Figure 1: ∘ 0.25-quantile, • 0.5-quantile, ⋄ 0.75-quantile

D.2 Temporal development of $q_\alpha(\Delta_{p|\bar{q}})$

D.2.1 Estimated autocorrelation for $q_\alpha(\Delta_{p|\bar{q}})$

Ar(p)	variable	$p = 1$	$p = 2$	$p = 3$
Session 2	$q^*_{0.5}(\Delta_{p|\bar{q}})$	0.3296	-0.7486	-
	$q^*_{0.75}(\Delta_{p|\bar{q}})$	0.0308	-0.7267	-
	$avg_{lastq=0.2}$	-0.5298	-	-
Session 3	$avg_{lastq=0.2}$	-0.7191	-	-
Session 4	$avg_{lastq=0.2}$	-1.1358	-0.6879	-

D.2.2 Regression of estimated AR(p)time series

Session	$AR(p)(q_\alpha(\Delta_{p|\bar{q}}))$	regressor	dependence	β_0	β_1	$p(\beta_0)$	$p(\beta_1)$	R^2_{korr}
Sess. 2	$AR(2)(q^*_{0.5}(\Delta_{p|\bar{q}}))$	$(\bar{p}_{lastq=0.2})$	linear	-0.971	0.357	$p < 0.01$	$p < 0.02$	0.60
	$AR(2)(q^*_{0.75}(\Delta_{p|\bar{q}}))$	$(\bar{p}_{lastq=0.2})$	linear	-1.138	0.309	$p < 0.01$	$p < 0.05$	0.42

D.2.3 Regression of autocorrelation-corrected $q_\alpha(\Delta_{p|\bar{q}}) = \mu(\beta_0, \beta_1, (\bar{p}_{lastq=0.2})$

Sess.	$q_\alpha(\Delta_{p\|\bar{q}})$	dependence	β_0	β_1	β_2	$p(\beta_0)$	$p(\beta_1)$	$p(\beta_2)$	R^2_{korr}
1	$q_{0.25}(\Delta_{p\|\bar{q}})$	quadratic	-1.357	1.092	-0.161	$p < 0.05$	$p < 0.06$	$p < 0.15$	0.70
	$q^*_{0.5}(\Delta_{p\|\bar{q}})$	logarithmic	0.465	0.463	-	$p < 0.04$	$p < 0.10$	-	0.28
	$q^*_{0.75}(\Delta_{p\|\bar{q}})$	linear	1.614	0.021	-	$p < 0.01$	$p < 0.9$	-	-0.16
2	$q_{0.25}(\Delta_{p\|\bar{q}})$	logarithmic	-0.360	0.732	-	$p < 0.04$	$p < 0.01$	-	0.70
	$q^*_{0.5}(\Delta_{p\|\bar{f}})$	quadratic	0.596	0.529	-0.143	$p < 0.06$	$p < 0.06$	$p < 0.03$	0.78
	$q^*_{0.75}(\Delta_{p\|\bar{f}})$	compound	2.916	0.857	-	$p < 0.01$	$p < 0.01$	-	0.23
3	$q_{0.25}(\Delta_{p\|\bar{q}})$	linear	-1.282	0.408	-	$p < 0.04$	$p < 0.04$	-	0.47
	$q_{0.5}(\Delta_{p\|\bar{q}})$	inverse	0.895	-0.135	-	$p < 0.01$	$p < 0.80$	-	0.11
	$q^*_{0.75}(\Delta_{p\|\bar{q}})$	logarithmic	1.883	-0.353	-	$p < 0.01$	$p < 0.15$	-	0.20
4	$q_{0.25}(\Delta_{p\|\bar{q}})$	linear	-0.951	0.205	-	$p < 0.02$	$p < 0.02$	-	0.58
	$q_{0.5}(\Delta_{p\|\bar{q}})$	linear	-0.100	0.161	-	$p < 0.71$	$p < 0.03$	-	0.56
	$q_{0.75}(\Delta_{p\|\bar{q}})$	quadratic	1.220	-0.255	0.054	$p < 0.01$	$p < 0.28$	$p < 0.21$	0.12

D.3 Temporal development of $\Delta_{p|\bar{f},q} = \{p|q, f = 0.5\} - \{p|q, f = 0.05\}$

D.3.1 $\Delta_{p|\bar{f},q} = \{p|q = 0.2, f = 0.5\} - \{p|q = 0.2, f = 0.05\}$

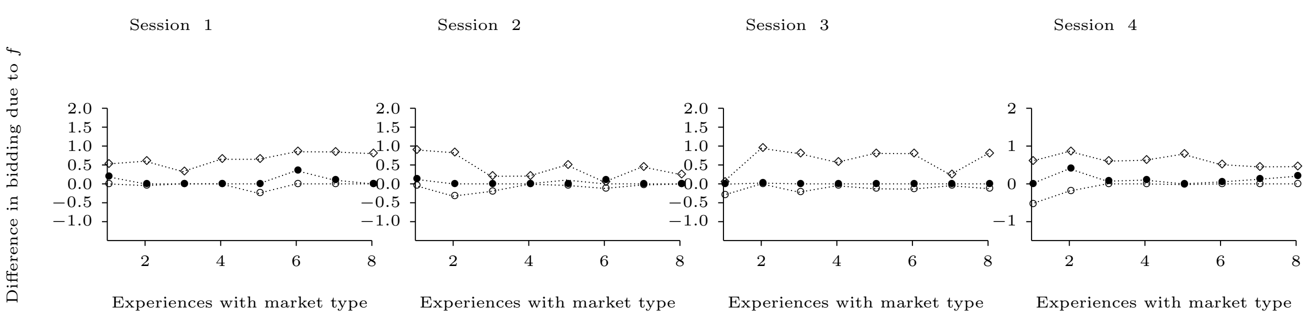

Figure 2: ○ 0.25-quantile, ● 0.5-quantile, ◇ 0.75-quantile

D.3.2 $\Delta_{p|\bar{f},q} = \{p|q = 0.6, f = 0.5\} - \{p|q = 0.6, f = 0.05\}$

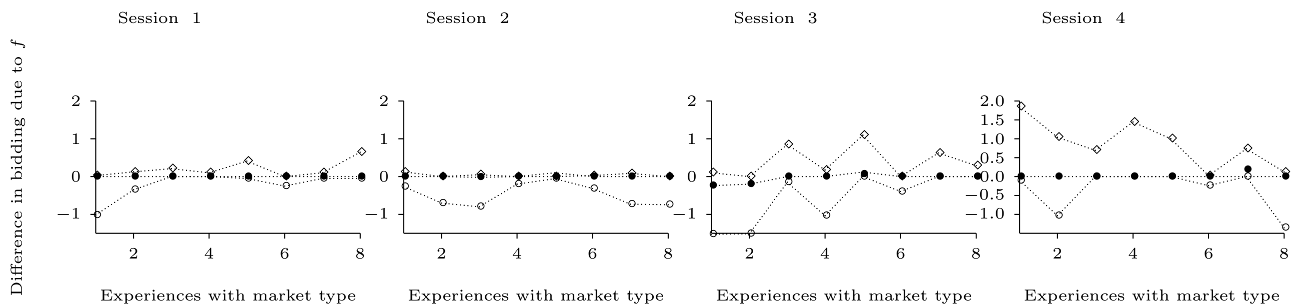

Figure 3: ∘ 0.25-quantile, • 0.5-quantile, ⋄ 0.75-quantile

D.3.3 Temporal dynamics of $q_\alpha(\Delta_{p|\bar{f},q})$

D.3.3.1 Estimated autocorrelation for $q_\alpha(\Delta_{p|\bar{f},q=0.2})$

Ar(p)	variable	$p = 1$	$p = 2$	$p = 3$
Session 3	$q^*_{0.75}(\Delta_{p|\bar{f},q})$	-0.6291	-	-

D.3.3.2 Regression of autocorrelation-corrected $q_\alpha(\Delta_{p|\bar{f},q=0.2}) = \mu(\beta_0, \beta_1, t)$

Sess.	$q_\alpha(\Delta_{p\|\bar{f},q=0.2})$	dependence	β_0	β_1	β_2	$p(\beta_0)$	$p(\beta_1)$	$p(\beta_2)$	R^2_{korr}
1	$q_{0.25}(\Delta_{p\|\bar{f},q=0.2})$	-	-	-	-	-	-	-	-
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.2})$	cubic	0.319	-0.287	0.074	$p < 0.08$	$p < 0.08$	$p < 0.08$	0.30
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.2})$	linear	0.201	0.028	-	$p < 0.01$	$p < 0.03$	-	0.53
2	$q^*_{0.25}(\Delta_{p\|\bar{f},q=0.2})$	linear	-0.101	0.012	-	$p < 0.05$	$p < 0.20$	-	0.13
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.2})$	inverse	-0.005	0.054	-	$p < 0.72$	$p < 0.11$	-	0.28
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.2})$	inverse	0.075	0.403	-	$p < 0.26$	$p < 0.03$	-	0.52
3	$q^*_{0.25}(\Delta_{p\|\bar{f},q=0.2})$	logarithmic	-0.137	0.029	-	$p < 0.01$	$p < 0.02$	-	0.59
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.2})$	-	-	-	-	-	-	-	-
	$q^*_{0.75}(\Delta_{p\|\bar{f},q=0.2})$	inverse	0.409	-0.284	-	$p < 0.01$	$p < 0.19$	-	0.15
4	$q^*_{0.25}(\Delta_{p\|\bar{f},q=0.2})$	logarithmic	-0.203	0.118	-	$p < 0.01$	$p < 0.01$	-	0.74
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.2})$	-	-	-	-	-	-	-	-
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.2})$	linear	0.390	-0.019	-	$p < 0.01$	$p < 0.1$	-	0.29

D.3.3.3 Estimated autocorrelation $q_\alpha(\Delta_{p|\bar{f},q=0.6})$

Ar(p)	variable	$p = 1$	$p = 2$	$p = 3$
Session 2	$q^*_{0.25}(\Delta_{p\|\bar{f},q})$	0.4070	-0.7018	-
Session 3	$q^*_{0.75}(\Delta_{p\|\bar{f},q})$	-0.5856	-	-

D.3.3.4 Regression results estimating $q_\alpha(\Delta_{p|\bar{f},q=0.6}) = \mu(\beta_0, \beta_1, \beta_2, t)$

Sess.	$q_\alpha(\Delta_{p\|\bar{f},q=0.6})$	dependence	β_0	β_1	β_2	$p(\beta_0)$	$p(\beta_1)$	$p(\beta_2)$	R^2_{korr}
1	$q_{0.25}(\Delta_{p\|\bar{f},q=0.6})$	logarithmic	-0.372	0.197	-	$p < 0.01$	$p < 0.02$	-	0.59
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.6})$	-	-	-	-	-	-	-	-
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.6})$	cubic	-0.239	0.302	-0.08	$p < 0.97$	$p < 0.19$	$p < 0.20$	0.30
2	$q^*_{0.25}(\Delta_{p\|\bar{f},q=0.6})$	inverse	-0.315	0.155	-	$p < 0.01$	$p < 0.14$	-	0.23
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.6})$	-	-	-	-	-	-	-	-
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.6})$	inverse	0.001	0.051	-	$p < 0.96$	$p < 0.10$	-	0.29
3	$q_{0.25}(\Delta_{p\|\bar{f},q=0.6})$	logarithmic	-0.818	0.400	-	$p < 0.01$	$p < 0.02$	-	0.64
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.6})$	logarithmic	-0.112	0.069	-	$p < 0.01$	$p < 0.02$	-	0.61
	$q^*_{0.75}(\Delta_{p\|\bar{f},q=0.6})$	logarithmic	0.071	0.173	-	$p < 0.59$	$p < 0.08$	-	0.33
4	$q_{0.25}(\Delta_{p\|\bar{f},q=0.6})$	quadratic	-0.523	0.255	-0.031	$p < 0.20$	$p < 0.22$	$p < 0.17$	0.13
	$q_{0.5}(\Delta_{p\|\bar{f},q=0.6})$	-	-	-	-	-	-	-	-
	$q_{0.75}(\Delta_{p\|\bar{f},q=0.6})$	logarithmic	0.879	-0.337	-	$p < 0.01$	$p < 0.03$	-	0.52

D.4 Determinants of hazard rates obtained via Cox' $\lambda(y|(q, avg_{t-1}, f)) = \lambda_0(y)e^{(q,avg_{t-1},f)}$[7,8]

variables	q	avg_{t-1}	f
Session 1	-3.74 ($p < 0.001$)	0.12 ($p < 0.001$)	-0.09 ($p < 0.720$)
Session 2	-2.16 ($p < 0.001$)	0.10 ($p < 0.004$)	-0.36 ($p < 0.130$)
Session 3	-4.21 ($p < 0.001$)	0.15 ($p < 0.001$)	0.26 ($p < 0.390$)
Session 4	-3.10 ($p < 0.001$)	0.11 ($p < 0.001$)	-0.71 ($p < 0.002$)

[7] with y indicating the duration of market abstention, q sellers' evaluation, f market entry cost, and avg_{t-1} reported average buyer gains of the last round.

[8] only coefficients and significance levels are reported here, indicating the impact of a variable on the end of market abstention, that is, market entry. Coefficients enter exponentially.

D.5 P-values for Nyblom-Hansen-tests on structural change within $\Delta_{p|\bar{f},q} = \mu(\beta_0, \beta_1, t)$ [9]

	q	session 1	session 2	session 3	session 4
$q_{0.25}(\Delta_{p\|\bar{f},q})$	$q = 0.2$	$p < 0.01$	$p < 0.02$	$p < 0.65$	$p < 0.01$
	$q = 0.6$	$p < 0.35^*$	$p < 0.42^*$	$p < 0.34$	$p < 0.34$
$q_{0.5}(\Delta_{p\|\bar{f},q})$	$q = 0.2$	$p < 0.18^*$	$p < 0.66$	$p < 0.04$	$p < 0.59$
	$q = 0.6$	$p < 0.02$	$p < 0.02$	$p < 0.54^*$	$p < 0.02$
$q_{0.75}(\Delta_{p\|\bar{f},q})$	$q = 0.2$	$p < 0.40$	$p < 0.03$	$p < 0.05$	$p < 0.09$
	$q = 0.6$	$p < 0.02$	$p < 0.03$	$p < 0.10^*$	$p < 0.01$

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[9] {*} indicates $p > 0.1$ for Nyblom-Hansen, where a majority of other tests display $p << 0.1$.

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