Information Transmission through Bargaining: Experimental Evidence*

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March 24, 2017

Abstract

Information asymmetries are often detrimental to both trade and efficiency. Bargaining may improve outcomes in such situations, as it allows for repeated interactions through which agents can transmit relevant information. We design an experiment to examine the information transmission properties of bargaining in markets that suffer from adverse selection. In line with theory, we find that frictions are essential to generate trade of high quality goods and that competition among uninformed parties further amplifies this positive effect. In contrast, we find no evidence for the prediction that transparency (the observability of offers among competitors) hinders information transmission. Unlike in the equilibrium of the model, the observability of offers increases competitive behavior of buyers and reinforces the seller's monopoly power. The effect is most pronounced for risk-averse buyers, who bid aggressively in a fashion reminiscent of effects witnessed in first-price auctions.

JEL Classification: C92, C70, D82

Keywords: Adverse Selection, Bargaining, Competition, Experiment, Information Transmission, Lemons, Monopoly, Screening

*We thank seminar participants at various institutions for helpful comments.

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1 Introduction

The presence of informational asymmetries in markets can have a devastating effect on trade and efficiency. Prominent examples are situations in which the presence of low quality goods reduces the buyers' willingness to pay, driving sellers of higher quality out of the market. This is usually referred to as *adverse selection* (Akerlof, 1970). The reason markets collapse under adverse selection is the inability of the price mechanism to convey information about the goods' qualities: in equilibrium a single price prevails that cannot accurately reflect the different reservation costs of the sellers.

Numerous institutions are potentially impaired by an information differential between buyers and sellers; among others trading platforms such as eBay, the market for used cars, the housing market and more generally any asset markets. Yet, the aforementioned institutions do not fall under Akerlof's static set-up since sellers typically have several chances of selling their goods. In a dynamic setting, the alternative to not trading today is to trade in the future. This can have a correcting effect on rate of trade and a partial alleviation of the adverse selection effect. The reason is that delay is costly and hence by rejecting offers a seller can endogenously signal her type – i.e. the quality of the good that she has for sale.[1]

The ability of repeated interactions to promote trade persists across a wide range of market institutions, including bilateral bargaining (Evans, 1989; Vincent, 1989; Deneckere and Liang, 2006), when several uninformed agents compete for a single seller (Hörner and Vieille, 2009a) or in large decentralized markets where agents meet in pairs over several periods (Blouin and Serrano, 2001; Moreno and Wooders, 2010, 2016; Virag, 2016). In the presence of competition, however, it turns out that the effectiveness of bargaining as a mechanism to transmit information critically depends on the transparency of a trading institution (Hörner and Vieille, 2009a; Kim, 2015, 2016). Think of transparency as a situation where buyers observe other buyers' previous offers. Without transparency buyers only knows how long the good has been for sale. For example, online trading platforms often display previous offers but eBay has recently also introduced the possibility for a seller to privately negotiate with a buyer without any information transmitted to other prospective buyers. The housing market serves as another example, as sellers may choose whether they reveal previous offers.[2]

In this paper, we experimentally examine bargaining in an adverse selection setting. We ask whether the possibility to make repeated offers and delay trade leads to information transmission, and how this depends on the degree of competition and transparency in the market. Note that adverse selection environments are well-suited for studying information transmission. The reason is that some belief-updating is required before uninformed agents can make offers that allow for

[1] We note that while the dynamic set-up improves information transmission, it also introduces delay as an additional source of inefficiency such that the effect on efficiency is ambiguous. This comes as no surprise given the result of Samuelson (1984) that no mechanism can lead to first-best efficiency if adverse selection is sufficiently strong. Samuelson also shows that a static mechanism is constrained efficient.

[2] Another example are "dark pools" in asset trading, which allow traders to make offers without releasing the details of the trade to the wider market. Dark pools are intended to help asset managers trade large blocks of shares without moving the market against them.

trade with high type sellers while also guaranteeing a positive expected profit. Our design consists of six treatments. We examine three institutions: (i) exclusive bargaining, (ii) competitive bargaining with private offers and (iii) competitive bargaining with public offers. When bargaining is competitive there are three buyers who compete for one seller. For each institution we run a treatment with frictions, i.e. there is an exogenous breakdown probability after each rejected offer, and a treatment without frictions, in which case there is a pre-announced number of bargaining rounds. All offers are made by the uninformed party (the buyer) and offers can be accepted or rejected by the informed party (the seller). We test the following two main hypotheses:

- *Frictions promote information transmission.* In the presence of frictions delaying an agreement is costly. Informed agents with high benefits from trade are therefore less willing to postpone agreement (or equivalently, more willing to accept lower prices) than agents with lower benefits. This allows uninformed agents to use specific price sequences to separate, or screen, the different types of the informed agent. As a result, bargaining can lead to trade even in the presence of adverse selection. Intuitively, low quality goods are sold early at a low price and high quality goods are sold late at a higher price.

- *The effect of competition on information revelation is ambiguous and depends on the observability of offers.* If offers are private, i.e. competing agents cannot observe each others' offers, competitive bargaining transmits more information than bilateral bargaining. The reason is that competition drives up prices, thereby speeding up the screening process. However, it is not true that competition is always beneficial for efficiency. If offers are publicly observable, competitive bargaining fails to transmit information. This is because uninformed agents have no incentive to overbid their competitors, as such offers would be countered by even higher offers in the future. Hence, offers stay low throughout the bargaining process, leading to low rates of trade and welfare levels.

There are several reasons why these observations warrant an empirical examination. The theoretical insights are based on sophisticated equilibrium reasoning and it is instructive to see if the predictions hold up at least qualitatively. Note that we are not interested in the quantitative predictions of equilibria but rather in their qualitative predictions. The effects of frictions and offer observability are intuitive and provide useful theoretical benchmarks. It is, however, unclear if they are the driving factors of behavior in an actual bargaining situation. An experiment allows us to explore this and potentially inspire new theories if the predicted effects are not observed or need to be qualified. The economics literature on bargaining has been very successful at combining theoretical and experimental work in order to provide new insights into human behavior – see below for a brief literature review. We follow this tradition by experimentally varying features of a trading environment that have been emphasized in the recent theoretical literature. Finally, our experiment is also informative for markets such as the housing market where it is common that an informed seller faces a series of potential buyers. How does competition on the uninformed side affect bargaining? Are sellers better off revealing information about past offers or should offers remain private?

We find that exclusive bargaining leads to screening of low type sellers, much like the qualitative predictions of the model. In particular, rates of trade with high type sellers are significantly boosted upwards in the presence of friction, while trade failures are common without frictions. The experimental results also confirm that competitive bargaining with private offers leads to successful information transmission and results in high efficiency. However, in contradiction to theory, the observability of offers does not substantially affect behavior in the experiment. Competitive bargaining with public offers performs equally well as competitive bargaining with private offers.

We discuss behavioral explanations for the high efficiency of competitive bargaining with observable offers: the presence of myopic sellers and inequity aversion. Both explanations are based on the idea that low type sellers cannot commit to rejecting all future offers. As a consequence, buyers' beliefs to be matched with a high type seller increase over time, and therewith the willingness to offer high prices. However, neither approach predicts that the differences in behavior between competitive bargaining with private and public offers vanish.

The individual-level analysis uncovers two further reasons why bargaining with observable offers promotes efficiency. First, we document that the observability of offers exacerbates the sellers' monopoly power. Sellers are less likely to accept a given offer if it is observable, a finding that is not in line with the theoretical predictions. We also witness fiercer competition between buyers when offers are observable. This is true in particular for risk averse buyers who are *more* likely to trade than their less risk averse counter-parts. This is in contrast to what we observe under exclusive bargaining, where risk aversion among buyers leads to lower rates of trade. The tendency that risk-averse buyers trade more frequently under competitive bargaining is an effect reminiscent of aggressive bidding in a first-price auction (e.g. Goeree, Holt and Palfrey, 2002).

Our main contribution is multi-fold. We show that, reassuringly, the mechanism so frequently studied in the theoretical literature on bargaining under incomplete information is empirically relevant: in the presence of time frictions, bargaining mitigates trade failures due to asymmetric information. This is not an obvious finding. It is well-known that people sometimes have difficulties updating beliefs according to Bayes' rule (Eyster and Rabin, 2005; Esponda, 2008). Moreover, our experiment suggests that the details of a trading institution may not be as important as one would expect in theory. Competition increases efficiency independently of the observability of offers. While we provide several insights into why transparency has no strong effect in our experiment, it will be instructive to explore the phenomenon in more detail in future research. Finally, the experimental results demonstrate that the impact of risk aversion crucially depends on the degree of competition. If bargaining is bilateral, risk aversion leads to longer delays before an agreement is reached and hence lowers efficiency. Using a different experimental design, the latter effect is also documented in Bochet and Siegenthaler (forthcoming). The finding that risk aversion on the uninformed market side promotes trade when bargaining is competitive is new and striking to us.

There is a well-established experimental literature on bargaining under incomplete information.[3]

[3]We do not attempt to provide a comprehensive review. See Roth and Malouf (1979), Roth and Murnighan (1982)

The experimental studies closest to our paper are Rapoport, Erev and Zwick (1995) and Reynolds (2000). Both study a bargaining game with the uninformed party as the proposer. They focus on the Coase Conjecture, which states that a monopolist seller will have to sell its product at marginal costs, because she is in effect in price competition with herself over several time periods. In line with this, both papers find that price sequences are decreasing and the informed party engages in "demand withholding", i.e. offers that would be acceptable are rejected because of the expectation that future offers will be even more profitable.[4] Such effects also play a role in our experiment. However, we focus on information revelation and its relationship with frictions, offer observability, and competition. Moreover, we study a setting with interdependent valuations where theory predicts trade failures due to adverse selection, while valuations are independent in Rapoport et al. (1995) and Reynolds (2000).

Our paper is also related to Forsythe, Kennan and Sopher (1991). In their experiment, one bargainer is informed if the state is good or bad. The treatments vary whether efficiency is attainable under the optimal mechanism. This general approach allows Forsythe et al. to test the explanatory power of truth-telling constraints in free-form bargaining (subjects can send hand-written messages for a period of ten minutes). The experiment shows that truth-telling constraints indeed drive the occurrence of trade failures. In our experiment, subjects always face a situation in which inefficiencies are unavoidable. We explore to what extent bargaining improves outcomes, and how the answer depends on the trading institution.

Our experiment is also relevant for the experimental literature on price dispersion. The literature examines price setting in decentralized markets with search or discounting costs. An important prediction is that price offers correspond to the monopoly price if buyer-seller meetings are bilateral and tend to approach Bertrand pricing if a seller meets more than one buyer simultaneously. Price dispersion exists in intermediate cases. Cason and Friedman (2003) and Cason and Noussair (2007) find evidence in favor of the theoretical predictions, while the results in Davis and Holt (1996) and Abrams, Sefton and Yavas (2000) suggests that theory may not predict outcomes well. In our setting, all meetings are one-on-one. If offers are observable (only then), the monopoly price of 0 should prevail for trades with a low type seller.

Finally, there is a literature starting with Abreu and Gul (2000) that examines the effects of obstinate or behavioral types in bargaining. Obstinate types commit to a certain behavior (e.g. to reject any offer below a certain price) at the start of the bargaining process. The presence of such types has interesting implications, because rational players have an incentive to behave as if they were obstinate. Embrey et al. (2015) confirm the existence of such effects experimentally.

and Roth and Schoumaker (1983) for seminal contributions and Mitzkewitz and Nagel (1993), Straub and Murnighan (1995), Croson (1996), Rapoport, Sundali and Seale (1996), Güth and Van Damme (1998), Nagel and Harstad (2004) for ultimatum games with incomplete information. See also Cason and Reynolds (2005) and Embrey, Fréchette and Lehrer (2015) who study the impact of bounded rationality in bargaining.

[4] Both studies also find substantial deviations from the comparative statics predictions of the model, for instance the effects of changes in the discount factor or time horizon. See also Cason and Reynolds (2005) for a discussion of bounded rationality in the bargaining context. More generally, these papers are part of a literature showing how matching, search, and time frictions can alleviate informational asymmetries, see also Bochet and Siegenthaler (forthcoming) and Siegenthaler (2017).

Fanning (2016) looks at the interaction of deadlines and obstinate types. Fanning (2014) provides a discussion in the context of bargaining under incomplete information.

The remainder of the paper is organized as follows. The next section presents the model. Section 3 presents the experimental design. In Section 4, we provide the theoretical predictions for each treatment and derive four hypotheses that will guide our data analysis. Section 5.1 presents the main results. In Section 5.2, we analyze behavior on the individual level. Finally, Section 6 concludes.

2 Model

A seller and $n \geq 1$ buyers bargain over the price at which a single, indivisible good is traded. The seller can be of two types $\theta = \{L, H\}$, i.e. the good is either of low (L) or high (H) quality. The seller's reservation costs are c_L as a low type and c_H as a high type. The buyers' valuations are v_L for a low quality and v_H for a high quality good. We assume positive gains from trade for both qualities, i.e. $v_L > c_L$ and $v_H > c_H$. The seller's type is private information. At the start of the game, buyers have a prior belief $q \in [0, 1]$ that the seller is a high type.

Bargaining takes the following form. All offers are made by the buyers. Buyers queue up to sequentially make offers to the seller. For instance, with three buyers the game starts with the lowest-indexed buyer offering a price to the seller. If the seller rejects the offer, buyer 1 joins the end of the queue and buyer 2 is asked to make the next offer. If buyer 2's offer is also rejected, it is buyer 3's turn. If buyer 3's offer is rejected, buyer 1 returns to make another offer and so on. The game ends if the seller accepts an offer. If price offer p is accepted by a type θ seller, the buyer who made the offer earns $v_\theta - p$ and the seller earns $p - c_\theta$. Buyers who do not trade earn 0. The game may also end if the bargaining process breaks down before the seller accepts an offer. Specifically, whenever an offer is rejected, there is a continuation probability $r \in (0, 1)$ that the next stage is entered. With probability $1 - r$ the bargaining process ends. In this case, everyone earns 0.

The model covers bilateral or *exclusive* bargaining when $n = 1$. When $n > 1$, bargaining is said to be *competitive*. In the presence of competition, the observability of offers will turn out to be crucial. Offers are said to be *private* if buyers can only observe their own past offers. Offers are *public* if buyers observe the full price sequence offered to the seller.

3 The Experiment

3.1 Experimental Design

There are six treatments. All treatments are based on the model introduced in the previous section with the following set of parameters.

Experimental parameters: the buyers valuations are $v_H = 23$ and $v_L = 10$, the seller's costs are $c_H = 16$ and $c_L = 0$, the probability of a high quality seller is $q = 1/3$. The treatments vary

Table 1: Experimental Design

Treatment	EF	ENF	PrF	PrNF	PuF	PuNF
Subjects	48	48	48	36	48	36
Sessions	4	4	4	3	4	3
Prob. H-type (q)	1/3	1/3	1/3	1/3	1/3	1/3
Continuation Prob. (r)	0.9	–	0.9	–	0.9	–
Stage of Breakdown (T)	random	known	random	known	random	known

the presence or absence of frictions and whether there is competition between buyers. If there is competition, offers are either private or public. Table 1 displays the different treatments. We discuss each treatment in sequence.

EF (exclusive bargaining with frictions): In treatment EF, we set $n = 1$ and $r = 0.9$. Hence, there is a single buyer making repeated offers to the seller. Offers can be made from the discrete grid $\{0, 0.01, 0.02, ..., 23\}$. If an offer is rejected, bargaining ends with a probability of 10%. If bargaining continues, the buyer can make another offer. We do not require offers to be increasing over time. Treatment EF is the baseline treatment. Comparing it to ENF allows examining the impact of frictions on information transmission. Comparing EF to PrF and PuF provides insights about the effects of competition.

ENF (exclusive bargaining without frictions): Treatment ENF is identical to EF, except that there are no frictions. Hence, instead of a random breakdown due to r, there is a pre-announced stage T after which the bargaining process ends. The number of available bargaining stages follows the same distribution as the realized random breakdown stages in EF.[5]

PrF (competitive bargaining with private offers and frictions): In treatment PrF, the number of buyers is $n = 3$. The three buyers only observe their own past offers. The continuation probability remains at $r = 0.9$.

PrNF (competitive bargaining with private offers and no frictions): Treatment PrNF removes the frictions from PrF, i.e. there is a pre-announced final stage T.

PuF (competitive bargaining with public offers and frictions): In treatment PuF, we keep the number of buyers and the continuation probability the same as in PrF, i.e. $n = 3$ and $r = 0.9$. However, the three buyers now observe all previous offers.

PuNF (competitive bargaining with public offers and no frictions): Treatment PuNF removes the frictions from PuF, i.e. offers are observable and there is a pre-announced final stage T.

[5] For instance, after session one of EF, the stages of breakdown observed in bargaining games one to ten were used to determine the pre-announced number of stages T in each bargaining game of session one of ENF. This was done for each session (the number of stages differs between sessions of the same treatment).

3.2 Risk Elicitation Task

Subjects also participated in a risk elicitation task. At the end of each session, subjects were presented six lotteries which they could either accept or decline. Each lottery gave a 50-50 chance between winning 6 CHF or losing an amount of either 2, 3, 4, 5, 6 or 7 CHF. One of the six lotteries was randomly selected for payment. In case the selected lottery was declined, no additional earnings or losses were realized. We chose the risk elicitation task, because the fact that the lotteries may result in a loss is consistent with the bargaining game.[6]

3.3 Procedures

We ran four sessions for treatments EF, ENF, PrF and PuF and three sessions for PrNF and PuNF. Each session was composed of twelve participants. Upon arrival, subjects were asked to read the instructions (available in the online appendix) and complete several control questions. Subjects played the bargaining game ten times. At the beginning of each bargaining game, subjects were randomly assigned the role of a buyer or a seller. In EF and ENF there were six buyers and six sellers. In the treatments with competition, there were nine buyers and three sellers. We used stranger matching.[7] Seller types were drawn at the beginning of each bargaining game, using $q = 1/3$, and revealed to the seller but not the buyer(s).

The experiment took place in fall 2013 and spring 2015 at the experimental laboratory of the University of Bern. We ran 22 sessions with a total of 264 participants. Programming was done in z-Tree (Fischbacher, 2007). A session lasted approximately 75 minutes and average earnings were 35 CHF, including a show-up fee of 15 CHF. At the time the sessions were conducted, 1 CHF corresponded to 1 USD.

4 Behavioral Hypotheses

This section derives the theoretical benchmarks for each treatment, highlighting the importance of frictions in enabling trade with high quality sellers and the crucial role the observability of offers plays in competitive bargaining environments. The equilibrium rates of trade and efficiency are summarized in Table 2. We next describe the (on-path) equilibrium behavior for each treatment. The equilibrium concept is Perfect Bayesian Equilibrium.[8] Before we start with the description of the different equilibria in our treatments, we should point out that we are not interested in the

[6]The lottery task is sometimes used to measure loss aversion, see Fehr, Herz and Wilkening (2013) for a discussion.

[7]To keep the probability to be matched with the same person in two consecutive bargaining games comparable across treatments, subjects were divided into two groups of six at the beginning of a session in EF and ENF, and then rematched within this group. We observed no trend or changes in behavior across the ten bargaining rounds, indicating that the matching successfully induced subjects to treat each bargaining round as a separate game. We also ran two sessions of PuF with fixed roles, but did not detect any differences in behavior.

[8]Equilibrium strategies are not unique for all bargaining environments, but all equilibria of a given environment follow similar patterns and result in the same equilibrium outcome. For simplicity, we will therefore focus on one equilibrium per treatment. All proofs can be found in the online appendix. The proofs refer to the variation that our game/model imposes compared to the one constructed by Hörner and Vieille (2009a).

quantitative predictions of our equilibria. As will be clear below, the description of equilibria is at time intricate and involve the play of mixed strategies. Instead what interest us are the qualitative predictions behind the equilibrium constructions.

The qualitative predictions are intuitive, and along the way we will state several hypotheses up for testing with our experimental design. The hypotheses rank the different bargaining environments in terms of their information transmission properties. Our measure for information transmission is the rate of trade of high type sellers: the faster information is revealed, the earlier buyers are willing to offer prices acceptable to the high type seller.[9]

EF: There is a unique equilibrium in EF. The buyer uses prices offers to acquire information about the seller's type. Each rejection by the seller moves the buyer's belief towards the high type. The strategy of the buyer is to follow a finite and increasing price sequence such that the low type seller is indifferent between accepting and delaying acceptance in each stage. In the second to last stage, a low type that has rejected all previous offers then accepts with probability 1. The sequence ends with an offer of c_H which is accepted by the high type seller. Typical of the presence of adverse selection, the low type seller gets an informational rent while the high type gives up all the undiscounted surplus $(v_H - c_H)$ to the buyer. Note how the probability of breakdown is an essential ingredient for screening to take place, and at the same time a source of efficiency loss compared to the first-best outcome.

Assuming the experimental parameters, the buyer uses the price sequence $(7.7, 8.5, 9.4, 10.5, 11.7, 13, 14.4, 16)$. The monotonically increasing price allows the buyer to exhaust the low type seller's patience before trade with a high type takes place. The corresponding ex ante acceptance probabilities of the low type seller are $(0.22, 0.15, 0.12, 0.1, 0.1, 0.1, 0.21, -)$. High type sellers accept in stage 8. Trade is therefore reached with both seller types, unless the breakdown occurs before the buyer has made an offer of 16.[10]

ENF: In the absence of frictions, screening cannot materialize. The buyer offers 0 in all stages. The low type seller accepts the first offer with a probability of 0.78. The buyer updates his belief to be matched with a high type seller to 16/23, which makes him indifferent between offering 0 and 16 if he were to make a take-it-or-leave-it offer. The low type seller rejects all further offers up to stage $T-1$ and accepts for sure in stage T. In contrast to EF, high type sellers never trade in ENF. The reason is that waiting entails no costs and thus the low type seller would always postpone acceptance if the buyer were to make a high offer in the future. This shows that the presence of frictions is crucial to enable trade with high type sellers.[11]

[9] An alternative and equivalent way to measure information transmission is to look at the opening offer. If the low type seller has to be indifferent between accepting and rejecting the opening offer, which is a requirement that holds in every equilibrium of our models, a higher opening offer must also imply higher expected future prices and thus higher rates of trade with high quality sellers.

[10] Stage t is reached with probability 0.9^{t-1}. The ex ante efficient welfare level is $1/3 * 7 + 2/3 * 10 = 9$. It is interesting to note that as long as the buyer's ex ante expected valuation $(1/3 * 23 + 2/3 * 10 = 14.33)$ falls short of the high quality seller's cost (16), inefficiencies do not disappear even as r approaches 1. In fact, the expected welfare under $r = 0.9$ of 6.04 is higher than the welfare of 5.21 if $r \to 1$. See Deneckere and Liang (2006) for a detailed discussion of the EF setting.

[11] The fact that expected welfare is higher in ENF than in EF (see Table 2) holds in general for sufficiently high

Table 2: Theoretical Rates of Trade and Efficiency

	EF	ENF	PrF	PrNF	PuF	PuNF
$P(Trade\|\theta = H)$	0.48	0	0.63	0.63	0	0
$P(Trade\|\theta = L)$	0.74	1	0.78	1	0.42	1
Ex Ante Efficiency	6.04	6.66	6.66	8.13	2.78	6.66

Ex ante efficiency is measured as the sum of expected payoffs of the buyer(s) and the seller, where the seller's type is weighted by q.

The predictions for EF and ENF lead to our first hypothesis. Recall that one setting is more successful than another in transmitting information if it exhibits a higher rate of trade with high type sellers.

Hypothesis 1. *More information is transmitted in EF than in ENF.*

We now turn towards competitive bargaining ($n = 3$).

PrF: We begin by discussing the equilibrium when bargaining is competitive and offers are private. In this case, the first buyer offers 10. The offer is accepted by the low quality seller with probability 0.42. The other buyers see that a rejection took place and update their belief that the seller is a high type from 1/3 to 6/13. This belief implies an expected payoff of 0 if the buyer chose to make an offer of 16. The low type seller's acceptance probability in period 1 is thus chosen to render the buyer indifferent between offering 16 and any "losing offer" that is rejected for sure. Each subsequent buyer offers 16 with probability 0.19 and an offer of 10 with probability 0.81, ensuring that the low type seller was indeed indifferent between accepting and rejecting the offer of 10 in period 1. Both types of the seller only accept the high offer of 16 from period 2 onwards. Notice how competition between buyers drives up prices (buyers make no profits) such that, as shown in Table 2, high quality sellers trade with a higher probability than under exclusive bargaining.

PuF: In every equilibrium of PuF, all buyers offer 0 in all stages. As in PrF, the offer in stage 1 is accepted by the low quality seller with probability 0.42 and the buyers update their beliefs from 1/3 to 6/13 (this must hold because buyers mix between 16 and 0 off the equilibrium path). From then on, all future offers are rejected until the bargaining process breaks down. Hence, high quality sellers do not trade and only some low quality sellers trade.

Hence, while PrF alleviates adverse selection relative to EF, competition has a detrimental effect on trade when offers are observable. Where does this stark difference between PuF and PrF come from? The reason is that in the equilibrium of PuF, an offer above 0 triggers an aggressive offer by the next buyer. An offer above 0 does therefore not increase the probability of getting accepted by the seller. Anticipating this, buyers refrain from raising offers above 0. In short, because offers are observable, the seller can reject high offers to induce even higher offers by subsequent buyers. On

r. This does not imply that ENF is always preferable from a social perspective. For instance, in some circumstances one may want to maximize the "liquidity" (trading rates) of a market rather than efficiency. Moreover, frictions are often inherent in the underlying environment and not subject to choice of a market designer.

the other hand, in PrF buyers would have an incentive to slightly increase any offer below 10: this guarantees acceptance by low type sellers, as other buyers cannot condition their reaction on this unobservable deviation. This shows how offer transparency can have a negative effect on efficiency.

Table 2 shows that the three bargaining institutions EF, PrF and PuF can be ranked in terms of rates of trade with high type sellers as well as efficiency: competitive bargaining with private offers performs better than exclusive bargaining, which in turn dominates competitive bargaining with public offers. The ranking holds in general if r is sufficiently large.[12] We summarize the discussion in Hypotheses 2 and 3.

Hypothesis 2. *More information is transmitted in PrF than in EF.*

Hypothesis 3. *More information is transmitted in EF than in PuF.*

We conclude the section with a discussion of PrNF and PuNF.

PrNF: For the same reasons as in PrF, every offer up to and including stage $T-1$ is equal to 10. The low type seller accepts the first offer with probability 0.42 and all other offers up to $T-1$ are rejected. At $T-1$, the low type seller accepts with a positive probability (0.63) such that the last buyer's belief is 16/23. The last buyer offers 16 with probability 0.63 and 0 otherwise. The low type seller accepts in stage T. The high type seller accepts in stage T if the offer is 16.

PuNF: The same predictions as in PuF apply, except that a low type seller accepts for sure in stage T.

Note that low quality sellers trade with probability 1 if there is a commonly known final stage T. Moreover, in contrast to exclusive bargaining, Table 2 shows that the rate of trade with high quality sellers is independent of frictions.

Hypothesis 4. *If bargaining is competitive, information transmission is independent of frictions.*

5 Experimental Results

The discussion of the experimental results is split into two parts. In Section 5.1 we test the four hypotheses presented above. Section 5.2 examines the data on the individual level by identifying the most common price sequences used by the experimental subjects. We also establish some important effects of risk aversion.

5.1 Frictions, Competition and Information Transmission

Table 3 summarizes the experimental results. The entries show averages over all bargaining games in the respective category. The corresponding theoretical predictions are given in parentheses.

[12] Deneckere and Liang (2006) describe the outcome for large r in EF. Hörner and Vieille (2009b) provide the necessary arguments for PrF and PuF. In the online appendix, we show that their arguments go through for our setting.

Table 3: Averages of Key Outcome Variables

		Rate of Trade	Trading Price	Trading Stage	Opening Offer	Efficiency	Buyer Profit (if traded)	Seller Profit (if traded)
EF	*Overall*	0.61 (0.65)	10.35 (12.64)	4.69 (5.42)	4.97 (7.65)	5.69 (6.05)	2.84 (1.70)	6.42 (7.23)
	High	0.45 (0.48)	16.81 (16.00)	7 (8)	5.02 (7.65)	3.17 (3.35)	6.19 (7.00)	0.81 (0.00)
	Low	0.70 (0.74)	8.25 (10.95)	3.93 (4.14)	4.95 (7.65)	6.95 (7.39)	1.75 (-0.95)	8.25 (10.95)
ENF	*Overall*	0.67 (0.67)	7.50 (–)	7.82 (–)	4.03 (0.00)	6.43 (6.67)	4.02 (–)	5.63 (–)
	High	0.23 (0.00)	15.43 (–)	10.13 (–)	3.95 (0.00)	1.64 (0.00)	7.57 (–)	-0.57 (–)
	Low	0.88 (1.00)	6.45 (0.00)	7.51 (10.00)	4.07 (0.00)	8.83 (10)	3.55 (10.00)	6.45 (0.00)
PrF	*Overall*	0.82 (0.73)	12.71 (14.33)	3.68 (4.90)	7.34 (10.00)	7.42 (6.67)	1.57 (0.00)	7.44 (9.00)
	High	0.81 (0.63)	16.81 (16.00)	6.23 (6.40)	7.00 (10.00)	5.69 (4.38)	6.20 (7.00)	0.81 (0.00)
	Low	0.83 (0.78)	10.70 (13.5)	2.43 (4.15)	7.52 (10.00)	8.28 (7.81)	-0.70 (-3.50)	10.70 (13.50)
PrNF	*Overall*	0.85 (0.88)	11.52 (12.88)	6.31 (9.48)	6.75 (10.00)	7.85 (8.13)	1.68 (1.46)	7.58 (7.54)
	High	0.58 (0.63)	15.47 (16.00)	7.60 (10.00)	6.24 (10.00)	4.04 (4.38)	7.53 (7.00)	-0.53 (0.00)
	Low	1.00 (1.00)	10.23 (11.31)	5.89 (9.22)	7.03 (10.00)	10.00 (10.00)	-0.23 (-1.31)	10.23 (11.31)
PuF	*Overall*	0.79 (0.28)	13.28 (–)	3.86 (–)	7.18 (0.00)	7.14 (2.78)	1.00 (–)	8.02 (–)
	High	0.78 (0.00)	18.08 (–)	5.72 (–)	7.50 (0.00)	5.47 (0.00)	4.92 (–)	2.08 (–)
	Low	0.80 (0.42)	10.93 (0.00)	2.94 (1.00)	7.02 (0.00)	7.97 (4.17)	-0.93 (10.00)	10.93 (0.00)
PuNF	*Overall*	0.74 (0.67)	10.26 (–)	6.62 (–)	6.22 (0.00)	7.03 (6.67)	1.71 (–)	7.84 (–)
	High	0.31 (0.00)	15.13 (–)	9.00 (–)	6.03 (0.00)	2.15 (0.00)	7.88 (–)	-0.88 (–)
	Low	0.98 (1.00)	9.39 (0.00)	6.20 (9.22)	6.33 (0.00)	9.78 (10.00)	0.61 (10.00)	9.39 (0.00)

Averages over bargaining games with theoretical predictions in parentheses. Buyer and seller profits are conditional on having traded.

Results 1 to 4 provide a discussion of the four hypotheses. All non-parametric tests use matching group averages as the unit of observation.[13]

Result 1. *Under exclusive bargaining, more information is transmitted in the presence of frictions, i.e. the rate of trade with high type sellers is significantly higher in EF than in ENF.*

Support: The rate of trade with high quality sellers is 45% in EF and 23% in ENF (Mann-Whitney U, p=0.01). The average trading prices in EF are 8.25 with low type sellers and 16.81 with high type sellers (Wilcoxon signed-rank, p=0.03), implying that buyers were able to separate seller types. Information transmission was successful in EF: 79% of the trades with low type sellers occurred at an ex post individually rational price for the buyer, i.e. at a price below 10. The screening success in EF, i.e. the fraction of low type sellers trading at a price below 10, exceeds the theoretical prediction of 49% (Wilcoxon signed-rank, p=0.01). Result 1 confirms Hypothesis 1. □

Result 2. *Competition promotes information transmission if offers are private, i.e. the rate of trade with high type sellers is significantly higher in PrF than in EF.*

Support: The rate of trade with high type sellers is 81% in PrF, which is significantly larger than in EF (Mann-Whitney U, p=0.01). The increased trade frequency with high types in PrF comes at the cost of higher average trading prices with low type sellers, 10.7 in PrF versus 8.25 in EF (Mann-Whitney U, p=0.02). However, trading prices in PrF are still different between trades with low and high type sellers (Wilcoxon signed-rank, 0.07). The fraction of trades with low type sellers occurring at a price below 10 is 70%, better than the predicted 42% (Wilcoxon signed-rank, p=0.07). Result 2 confirms Hypothesis 2. □

Result 3. *Competition promotes information transmission if offers are public, i.e. the rate of trade with high type sellers is significantly higher in PuF than in EF and not significantly different between PuF and PrF.*

Support: The rate of trade with high quality sellers is 78% in PuF, which is significantly larger than in EF (Mann-Whitney U, p=0.01) and not significantly different from the one in PrF (Mann-Whitney U, p=0.76). The observed trading prices with low type sellers are also not different between PuF and PrF (Mann-Whitney U, p=1.00 for both types). The same applies to the fraction of trades with low types at individually rational prices, which is 69% in PuF (Mann-Whitney U, p=0.77). Result 3 rejects Hypothesis 3. □

Result 4. *The presence of frictions promotes information transmission even if bargaining is competitive, i.e. the rate of trade with high type sellers is significantly higher in PrF than in PrNF and significantly higher in PuF than in PuNF.*

[13] Hence, we have four independent observations (sessions) for PuF and PrF. We have eight independent observations for EF and ENF, where the twelve subjects in a session were separated into two groups of six who never interacted with one another.

Support: The difference in the rate of trade with high quality sellers in PuF (78%) and PuNF (31%) is significant (Mann-Whitney U, p=0.03). The difference between PrF (81%) and PrNF (58%) is not significant at the 10% level using a Mann-Whitney U test (p=0.11). The difference in the rate of trade between PrF and PrNF is, however, highly significant in a multilevel regression with individual and session random intercepts and robust standard errors (regression not reported). Moreover, pooling the competitive bargaining sessions with frictions and comparing them to the competitive bargaining sessions without frictions shows that frictions significantly increase the probability of trade with high types (Mann-Whitney U, p=0.01). This result rejects Hypothesis 4. □

So far, the focus was on high type sellers and information transmission, but for efficiency, low type sellers are equally important. Frictions tend to reduce rates of trade with low type sellers, because delaying trade gives rise to bargaining breakdowns. In line with this, trading rates with low type sellers are higher in ENF than in EF (Mann-Whitney U, p=0.004), higher in PrNF than PrF (Mann-Whitney U, p=0.03), and higher in PuNF than PuF (Mann-Whitney U, p=0.07). The next result summarizes the implications for efficiency.

Result 5. *Efficiency is significantly higher under competitive bargaining than exclusive bargaining. Frictions do not significantly affect efficiency within a bargaining institution.*

Support: Efficiency levels are 5.69 in EF, 6.43 in ENF, 7.42 in PrF, 7.85 in PrNF, 7.14 in PuF, and 7.03 in PuNF. PrF and PuF perform significantly better than EF (Mann-Whitney U, p=0.03 and p=0.09, respectively), while the difference between PrF and PuF is not significant (Mann-Whitney U, p=0.88). Mann-Whitney U tests show that the differences between EF and ENF (p=0.29), PrF and PrNF (p=0.29), and PuF and PuNF (p=1.00) are not significant. The efficiency levels are similar to the theoretical predictions for all treatments, except in PuF where in theory efficiency is much lower at 2.78. □

The reported results allow us to draw two main conclusions. First, frictions enable buyers to use price offers to extract information from sellers, which in turn promotes trade with high quality sellers. This conclusion holds independently of whether bargaining is exclusive or competitive. Recall that the only difference between the friction and no friction treatments is that the breakdown stage is random in the presence of frictions and pre-announced otherwise. Buyers seem to realize that the possibility of random breakdowns allows for effective screening of sellers. The second main insight is that both competition environments promote trade and information transmission. This was expected for private offers, but in contrast to the theoretical predictions the conclusion holds even when offers are public.

5.2 Individual-level Analysis

5.2.1 Price Sequences

Figure 1 presents an overview of the offers made in the experiment. In figure (a), rejected offers are represented as grey circles and accepted offers as black squares. The solid lines depicts smoothed

Figure 1: Price Offers

(a) Rejected & Accepted Offers

(b) Bargaining Games with High Offers

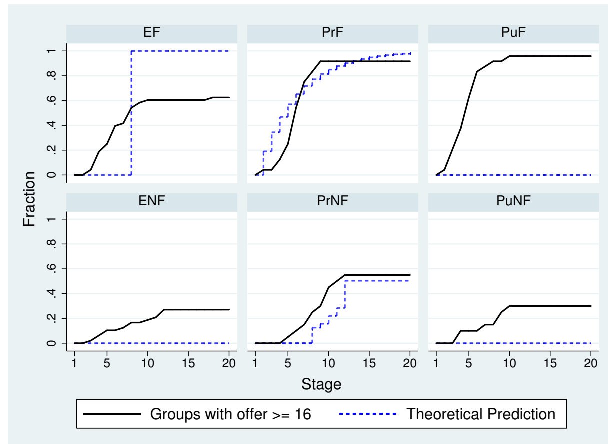


Figure (a): grey circles are rejected offers, black squares are accepted offers; jitter option (small noise) used to make offers distinguishable; solid lines are smoothed values of a local polynomial regression of offers on stage. Figure (b): fraction of bargaining games with at least one offer above 16 up to the respective stage; only observations with high type sellers and $T >= 8$ are included.

values of a local polynomial regression of offers on stage. It underestimates the steepness of the average price sequence, because later stages by construction include more buyers who are not willing to raise price offers. In other words, buyers who raise offers faster are likely to get accepted early in the game. To account for this, figure (b) depicts the fraction of bargaining games with at least one offer above 16 up to the respective stage. For instance, in EF the fraction of bargaining games with a high offer gradually increases up to stage 10 and then remains constant at 60%. The corresponding theoretical predictions are given by the dashed lines.[14]

In general, price offers increase quickly in PrF and PuF, increase somewhat slower in EF and PrNF and tend to be flat in ENF and PuNF. Treatments with frictions are successful at generating high offers. This is true in particular when there is competition and independently of the observability of offers. Figure (a) is indicative of the individual price sequences observed in the experiment. Notice that few offers are between 10 and 16, even in EF where such offers should be frequent. Moreover, figure (b) shows that in EF a high offer above 16 is observed in only 60% of the bargaining games. Hence, in contrast to the theoretical predictions, not all buyers raise offers over time. Taking a closer look at the offer sequences, it turns out that they fall into two main patterns:

- *Threshold screening:* A sequence of offers only acceptable to the low type seller (i.e. offers between 0 and 10) is followed by a sudden increase to an offer that covers the high type seller's

[14]Notice that figure (b) only includes bargaining games with a complete price sequence. In particular, we focus on bargaining games in which the seller is a high type and for which $T >= 8$, the number of stages that is theoretically required for trade with a high type seller in EF. These price sequences can be seen as complete, in the sense that they are not "interrupted" by an early exogenous breakdown or an acceptance by a low type.

Table 4: Offer Patterns

	EF		ENF		PrF		PrNF		PuF		PuNF	
Component	1	2	1	2	1	2	1	2	1	2	1	2
Mean	6.53	17.35	5.93	17.82	16.01	17.10	8.56	18.32	9.00	18.57	9.15	15.99
SE	1.66	1.61	2.41	1.10	4.87	0.45	0.98	1.05	2.11	1.15	0.56	2.70
Frequency	38%	62%	76%	24%	32%	68%	45%	55%	4%	96%	49%	51%

Two-component finite mixture model with cluster-robust (individual level) standard errors (SE). Components are assumed to be normal distributions.

reservation value of 16.

- *Flat price sequence:* All offers are between 0 and 10, typically around a price of 5, until the bargaining process stops.

We next estimate the frequency of the two patterns. Let y denote the maximum offer made by a buyer in a bargaining game with a complete price sequence, see footnote 14. We assume that the distributions of y is a mixture of two normal distributions. Table 4 lists the estimates of the corresponding finite mixture model. In treatment EF 62% of all bargaining games correspond to threshold screening, i.e. there is an offer above 16. On the other hand, the predominant pattern in ENF are flat prices. Moreover, almost all price sequences under competitive bargaining with frictions (PrF and PuF) correspond to threshold screening. In PrNF and PuNF both types of price patterns are common.

The unique equilibrium in EF is characterized by gradual screening, involving a number of offers between 10 and 16 (see Section 4). However, the dominant offer pattern involves jumps from below 10 to offers that exceed 16. Can we reconcile threshold screening with equilibrium reasoning? An interesting possibility to achieve this is related to some work by Abreu and Gul (2000). Their idea was to introduce obstinate bargaining types who are committed to never raise offers above a certain amount. Interestingly, rational players may want to mimic obstinate types in equilibrium. Embrey et al. (2015) provide experimental evidence supporting these predictions. A similar reasoning can be used to explain threshold screening in EF. Assuming the presence of obstinate buyers, there exists an equilibrium in which a rational buyer uses threshold screening. He starts by pretending to be an obstinate type who only makes offers below 10 and switches to a high offer when the belief to be matched with a high type is sufficiently high.[15]

An alternative explanation for the flat parts observed in many price sequences comes from the literature on cursed beliefs (e.g., Eyster and Rabin, 2005; Esponda, 2008). The literature shows that subjects may fail to correctly condition observed actions on private information held by others. In our setting, cursed buyers would not or only slowly update beliefs towards high types when observing rejections of low offers. They would therefore not be willing to make high offers later in the sequence. Disentangling the different possible reasons for the observed flat price sequences is an important question for future work.

[15] The full equilibrium characterization is intricate and beyond the scope of this paper. See Fanning (2014) for a discussion of obstinate types in the presence of incomplete information.

5.3 On the Role of Observability

The main deviation from theory in the experimental data is the failure of Hypothesis 3: high type sellers almost always trade in treatment PuF. Indeed, Table 3 shows that trading rates, opening offers, accepted offers, and the allocation of gains from trade in PuF are very similar to the results in PrF. Figure 1 confirms that on average buyers' price offers in PrF and PuF are practically equivalent. These observations also hold when restricting the analysis to the first bargaining game. In other words, it is not the case that behavior in PrF and PuF is initially different and only converges over time. It is worthwhile to note that in the experiment the history of offers was prominently displayed, covering the entire left-hand side of the computer screen. We are thus confident that the similarity of results between PrF and PuF cannot be explained by the possibility that subjects did not pay sufficient attention to the history of offers.

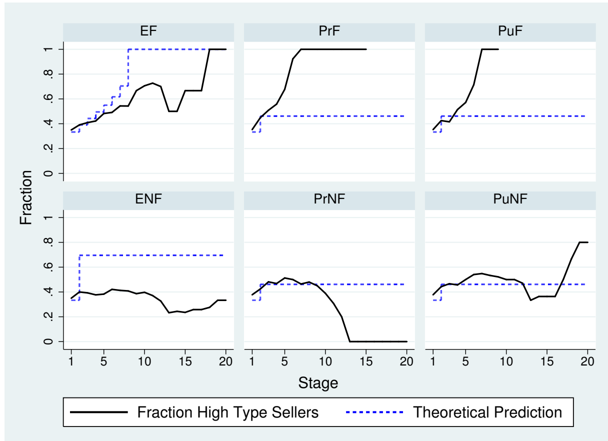
A modeling approach that captures the possibility of positive rates of trade with high type sellers in PuF is given in Hörner and Vieille (2009b). They assume that a seller is myopic with some probability in each stage, in which case she accepts any offer that covers her production costs. As a result, buyers gradually update beliefs until at some point trade with high type sellers must occur. This model is consistent with the data in some respects. Figure 2 depicts the ability of buyers to screen out low type sellers with low offers. Specifically, it depicts the fraction of high type sellers given that no offer above 16 has been made yet in the respective bargaining game. The dashed lines correspond to the theoretical prediction.[16] The figure shows that acceptance behavior in PrF and PuF is in line with the presence of myopic low type sellers who accept offers below 16 (in fact, below 10) also after stage 1. The figure also again confirms that frictions help screening, as only then the fraction of high types increases over time.

Going back to Figure 1 (a), we note that there were rarely offers below 5 in PrF and PuF. Sharing the surplus at least equally seems to be the lower bound of what low type sellers are willing to accept. The experimental literature on bargaining emphasizes the importance of inequity aversion, although mostly in the context of complete information environments (Güth, 1995). Can fairness preferences explain the behavior in PuF? Assume that there is a threshold below which offers are rejected. For higher offers, inequity concerns disappear (see e.g. Von Siemens, 2009). Let p be the offer and $\bar{p}$ the threshold (presumably, $\bar{p} = 5$ in our experiment). A low type seller's utility from accepting is p if $p \geq \bar{p}$. The utility from accepting an offer below $\bar{p}$ is smaller than his utility in the no trade outcome. With these preferences, the equilibrium in PuF is described by an initial offer of 5, followed by the future buyers mixing between 5 and 16 such that the expected offer is 5/0.9. Fairness concerns can thus generate trade with high type sellers.[17]

[16] The predictions are simplified for PrNF, where for stage $T-1$ there would be a jump to 16/23. Consider a given stage t. This stage does typically not correspond to $T-1$. However, for some it may and thus the true prediction would on average be slightly above the depicted line. Since the effect is negligible, we chose to not represent it in the figure.

[17] Inequity aversion modelled as in Fehr and Schmidt (1999) cannot explain positive rates of trade with high type sellers. There the utility from accepting an unfair offer p is $p - \alpha(5 - p)$, where α is a parameter measuring inequity aversion. In equilibrium, the initial offer is given by $p^* = 5\alpha/(1 + \alpha)$, yielding a utility of 0. All future offers have to be p^* as well. Note that in order to generate trade with high type sellers, the low type seller needs to have a positive

Figure 2: Fraction of High Type Sellers (Offers < 16)



Fraction of high type sellers among all sellers in a given stage, when no offer ≥ 16 has been made yet. The figure thus depicts the ability of buyers to screen out low type sellers with low offers.

It is likely that both myopic sellers and fairness concerns play a role in the experiment.[18] However, neither approach predicts such a strong similarity in behavior between PrF and PuF (also not the one discussed in footnote 17). For small probabilities of myopic sellers the equilibrium approaches the one in which all offers are 0. Regarding the fairness-based explanation, the opening offer in PuF should still be substantially below the one in PrF. A full answer to the question why the observability of offers does not affect outcomes as expected thus remains elusive.

However, we can provide some additional insights by taking a closer look at individual-level behavior. We next present two pieces of evidence showing that sellers benefit from observable offers in ways not captured in theory. In contrast to the equilibrium predictions, the observability of offers fuels competition between buyers and exacerbates the seller's monopoly power. The first piece of evidence concerns the seller's acceptance decisions.

Result 6. *Sellers tend to be more demanding in PuF than in PrF, as a given offer is less likely to be accepted if offers are observable.*

Support: Table 5 presents a set of multilevel regressions. The dependent variable in column 1 is the low type sellers' acceptance decisions. The difference between PuF and PrF indicates that low type sellers are less likely to accept an offer in PuF than in PrF (p=0.093), in contradiction to theory. A similar effect is found in column 2, where we restrict attention to high type sellers (p=0.103). Pooling the two types of sellers, we get p=0.066. Keep in mind that most offers were rather high already at the start of the bargaining game, diluting the incentives to reject offers.

utility from accepting the opening offer. One possibility to allow for this while staying in the framework of Fehr and Schmidt (1999) is to assume that sellers have different values of α that are private information.

[18] On the other hand, the winner's curse (e.g., Ball, Bazerman and Carroll, 1991) does not seem to play a role in our experiment, as buyers typically do not make losses. Likewise, difficulties related to mixed strategy equilibria (e.g., Ochs, 1995) would affect PrF to a larger extent than PuF. Buyers only mix in the former, but there we observe a behavior that is close to equilibrium play.

Table 5: Multilevel Regressions: Acceptance Behavior, Offers, and Trade

Dep. Var:	(1) Accept (Low)	(2) Accept (High)	(3) Offer	(4) Trade	(5) Trade (High)
Offer	0.073***	0.038***			
	(0.004)	(0.005)			
Stage	0.009	-0.002	0.716***		
	(0.009)	(0.002)	(0.161)		
PrF	-0.003	0.024*	0.622	-0.565***	-0.539***
	(0.045)	(0.013)	(0.677)	(0.090)	(0.121)
PuF	-0.103**	-0.005	1.736***	-0.695***	-0.716***
	(0.050)	(0.022)	(0.658)	(0.090)	(0.156)
RA			-0.354***	-0.030	-0.060**
			(0.125)	(0.022)	(0.029)
PrF × RA			0.475***	0.060**	0.098***
			(0.149)	(0.025)	(0.036)
PuF × RA			0.370**	0.100***	0.160***
			(0.158)	(0.024)	(0.042)
Constant	-0.254***	-0.267***	5.114***	0.564***	0.347***
	(0.061)	(0.047)	(0.713)	(0.101)	(0.114)
Period dummies	✓	✓	✓	✓	✓
N	982	937	3541	960	336

Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Linear multilevel models with individual and session random intercept. Baseline treatment: EF. RA denotes the risk aversion measure. Model (2) only includes observations with offers ≥ 16.

Sellers were also more likely to reject offers in PuF than in EF, while the same is not true for the comparison between PrF and EF. □

Column 3 in Table 5 examines buyer offers, column 4 buyers' overall probability to trade, and column 5 buyers' probability to trade with high type sellers. Risk aversion plays an important role in these regressions. The coefficient RA measures a buyer's risk aversion as elicited in the task described in Section 3.2.[19] Remarkably, the effects of risk aversion are qualitatively different between exclusive and competitive bargaining. The impact of risk aversion also differs depending on the observability of offers. This is our second piece of evidence showing that the seller benefits from offer transparency.

Result 7. *Risk aversion among buyers reduces prices and slows down trade in EF, but has the opposite effect if bargaining is competitive (PrF and PuF). The positive effect of risk aversion is particularly strong if offers are observable.*

Support: Column 3 shows that offers are higher under competitive bargaining than under exclusive bargaining. In line with the previous result, the effect is stronger when offers are observable. This effect is amplified for risk averse buyers. Risk averse buyers lower their offers in EF below the level

[19] Almost all subjects (97%) have a unique switching point from accepting less risky to rejecting more risky lotteries. Thus, we use the switching point as the risk aversion measure. The distribution of switching points does not significantly differ between treatments. Lottery choices do not depend systematically on subjects' earnings in the main part of the experiment.

of their less risk averse counter-parts. This makes intuitive sense, because postponing agreement allows for better screening of the low type seller and reduces the risk of offering a high amount to a low type seller. Competition reverses this effect. Risk averse buyers try to avoid the risk of not being able to trade. This pushes prices upwards. Column 5 confirms the same findings in terms of trading success: risk averse buyers are less likely to reach an agreement with the high type seller in EF, but more likely to trade with a high type seller if bargaining is competitive. Similar conclusions hold for column 4. The sum of the coefficients PrF $\times$ RA + RA is significant at the 10% and 5% level for columns 4 and 5, respectively; PuF $\times$ RA + RA is significant at the 1% level for both columns. Again, the effect of risk aversion is significantly stronger if offers are observable: comparing PuF $\times$ RA and PrF $\times$ RA yields a significantly larger increase in the probability of trade in PuF (p=0.007 in column 4 and p=0.103 in column 5). □

6 Conclusion

We conduct an experiment examining the information transmission properties of different bargaining institutions. Our choice of institutions is rooted in the theoretical literature, which shows that the ability of bargaining to transmit information depends on the presence of frictions as well as the transparency of offers, i.e. whether or not offers are observable among competitors.

The experimental results are qualitatively in line with the theoretical predictions for most treatments. In particular, the possibility to bargain – defined as repeated offers in the presence of frictions – leads to substantial rates of trade with high type sellers in an adverse selection environment. In line with bargaining theory, frictions are shown to be essential for this result. However, we find that the observability of offers does not affect rates of trade and realized efficiency under competitive bargaining. Competition between uninformed parties leads to consistently high efficiency levels in our markets, independently of whether offers are private or publicly observable. The deviations from equilibrium predictions can be explained by the presence of myopic sellers or by a form of inequity aversion. In addition, we identify interesting effects related to risk aversion and the seller's monopoly power (measured by her willingness to accept a given offer). Both push prices upwards when offers are observable.

Our results carry a positive message about the performance of markets with adverse selection. The data shows that the welfare-enhancing effects of competitive bargaining are robust to the information buyers have about their competitors' behavior. As a first step, we have provided possible explanations for the absence of an effect of transparency in our experiment. A full explanation of the puzzle requires additional work. Its exploration deserves some attention, however, because the transparency of offers is a potentially important variable for market designers. Experimental markets provide a valuable tool for pinning down the implications of transparency in different trading institutions.

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A Online Appendix

A.1 Proofs

Exclusive bargaining with frictions

The predictions follow from Deneckere and Liang (2006), who provide a full characterization of the unique equilibrium.

Exclusive bargaining without frictions

Samuelson (1984) shows that the buyer's optimal trading mechanism is to make a take-it-or-leave-it offer to the seller. In setting ENF, the buyer can obtain the same payoff as with a take-it-or-leave-it offer by offering 0 in each stage. Hence, this must be the equilibrium price sequence. The high type seller must reject all offers to avoid a loss. The low type seller is indifferent between accepting and rejecting in any period and supports the buyer's price sequence in equilibrium.

Competitive bargaining with private offers and frictions

Hörner and Vieille (2009b) provide the necessary arguments for the case of a single buyer and an infinite stream of one-stage buyers. Their argument goes through for our model, except for bullet point 2 on page 6. In particular, we need to show that buyers never offer a price between 10 and 16 in our setting.

Consider buyer i who makes an offer p such that $16 > p > 10$. The only reason a buyer may want to offer p is to screen the low type seller, i.e. this buyer expects with positive probability that he will reach a state when his belief strictly exceeds 6/13, such that an offer of 16 yields strictly positive expected payoff. In fact, buyer i must follow the same type of price sequence as under exclusive bargaining, i.e. a sequence that takes the form $(16 * 0.9^{ns}, 16 * 0.9^{n(s-1)}, \dots, 16)$ where s is a natural number. To see this, notice that buyers are only willing to offer p if this results in an informational advantage over other buyers. Beliefs thus need to differ across buyers after p is offered, as otherwise a buyer other than buyer i reaps the gains from offering 16 when beliefs exceed 6/13. Therefore, no buyer offers p with probability 1. Deneckere and Liang (2006) show that price sequences need to be of the form shown above (with $n = 1$) in order to set the low type seller indifferent between accepting in each stage. With $n > 1$ this could only be done by two separate buyers if they were certain about the realized choices of other buyers (no mixing).

When making the second to last offer $0.9^{n-1}16$, the belief to face a high quality seller must be 16/23. At this belief the buyer is indifferent between offering $0.9^n 16$ and 16. This ensures that a buyer does not want to offer slightly more than $0.9^{2n}16$ in his previous turn, because such an offer would trigger a higher expected offer in the next stage, obtained by mixing between $0.9^n 16$ and 16. At belief 16/23, offering $0.9^n 16$ yields an expected profit of $z[0.9^n(16/23)(23 - 16) + (1 - (16/23))(10 - 0.9^n 16)]$, where z is the probability no other buyer trades in between the two last offers of buyer i. This payoff is strictly smaller than the expected gain of offering 16 given by $16/23(23 - 16) + (1 - (16/23))(10 - 16)$ if $z < 1$. But $z < 1$ holds, since due to the buyers' mixing, there is a positive probability that no buyer follows the increasing price sequence and hence, offers above 16 occur with positive probability for the same reason they do in Hörner and Vieille (2009b) with an infinite stream of buyers. We have thus shown that there is no offer p such that $16 > p > 10$.

Competitive bargaining with private offers without frictions

In stage T, the buyer must offer 0 or 16. In fact, the buyer must mix between the two offers, i.e. his belief must be 16/23. If the buyer in T offered 0 for sure, the second to last buyer could offer slightly above 0 and guarantee acceptance. The same reasoning shows that the last buyer must offer 16 with a probability such that the expected offer is 10. If the buyer in T offered 16 for sure, the low type seller would not accept offers below 10 in any stage. Also, the buyers' belief before and in stage $T - 1$ cannot exceed 6/13. This belief implies an expected profit of 0 when offering 16. Otherwise at least one buyer would offer 16 before period T for sure. In all stages before stage $T-1$ only offers of 10 are accepted with positive probability (otherwise the seller could wait for the last stage), and there must be at least one such offer to move the buyer's belief to 6/13.

Competitive bargaining with public offers and frictions

Hörner and Vieille (2009b) provide the necessary arguments, once we show that their claim S2 on page 2 also holds for our model. As in PrF, this requires to show that buyers never offer a price strictly between 10 and 16. As in PrF, a buyer i is only willing to offer p such that $16 > p > 10$ if this results in an informational advantage over other buyers – i.e. after offering p buyer i's belief to face a high type seller must exceed the belief of all other buyers. Otherwise a buyer other than buyer i would reap the gains from buyer i's screening and offer 16 after buyer i's last screening offer $16 * 0.9^n$. Since offers are public, beliefs are identical across buyers. We have thus shown that there is no offer p such that $16 > p > 10$.

Competitive bargaining with public offers without frictions

For the same reasons as in PrNF, the buyer in stage T must have a belief of 16/23 that makes him indifferent between offering 0 and 16. Again as in PrNF, the offer in $T-1$ must be accepted with positive probability. However, since offers are observable, all offers between 0 and 10 need to result in a belief of 16/23 after a rejection, for otherwise the last buyer would not be willing to mix (off the equilibrium path). The buyer in $T-1$ offers 0, because this maximizes his payoff given that the acceptance probability is constant across offers below 10. Hence, all offers must be zero, otherwise the offer of 0 in stage $T-1$ would be rejected for sure. The first offer must be accepted such that buyers update beliefs to 6/13, to ensure that offers above 0 and below 10 are rejected for sure in $t = 2, \ldots, T-2$.