An Experiment on Partnership Protocols for Bilateral Trade with Incomplete Information

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Abstract

We study experimentally "partnership protocols" of the sort proposed by Kalai and Kalai (2010), for bilateral trade games with incomplete information. We utilize the familiar game analyzed by Chatterjee and Samuelson (1983) and Myerson and Sattherwaite (1983), with a buyer and seller with value and cost independently distributed uniformly on (0,100). The usual rules of the game are for the buyer and seller to submit price bids and asks, and for trade to occur if and only if the buyer's bid price exceeds the seller's ask price, in which case trade occurs at the average of the bid and the ask price. We compare the efficiency of trade and the nature of bid functions in this standard game to those in other versions of the game, including games in which cheap talk is allowed prior to trade (either before or after the traders know their own information, but without knowing each others' information), games with the formal mechanisms proposed by Kalai and Kalai available as an option for the traders to use, and games with both the mechanisms and cheap talk available. We consider both ex ante and interim mechanisms. That is, traders simultaneously choose whether to opt in to the mechanism either prior to knowing their own information, or after knowing their own information. In the last two versions of the game, cheap talk takes place prior to the opt-in decision.

We find that the formal mechanisms significantly increase the efficiency of trade in both the ex ante and interim cases. Specifically, in the baseline game, traders captured 73% of the available surplus (compared to a theoretical maximum of 84% possible with optimal strategies). Efficiency rises to 87% and 82% for the ex ante and interim mechanisms, respectively, and further rises to 90% and 84% when cheap talk is also allowed with the mechanisms. When only cheap talk is allowed, traders capture 81% (for ex ante talk), but only 70% (for interim talk). On average, 55% of trading pairs opt in to mechanisms when they are available.

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1. Introduction

Efficiency is a central concern in economics. In the study of strategic behavior in interactive decision theory (non-cooperative game theory), the Nash equilibrium and various refinements of Nash equilibrium are of primary importance as guidance for predicting behavior. But the inefficiency of many Nash equilibria is a concern in many contexts, both because of the sometimes extreme wastefulness implied, and because the equilibria often appear implausible as a prediction of real human behavior. The prisoners' dilemma is a well known and simple game that we will use for illustration, but the principles outlined here apply to two-person games generally, including (Bayesian) games of incomplete information. We report here the results of an experiment designed to investigate the efficacy of various "protocols" for enhancing efficiency in games. These protocols range from simply allowing players to communicate with one another prior to play ("cheap talk") to well-specified mechanisms that players may voluntarily "opt into" in order to ensure more efficient outcomes. We rely particularly on recent theoretical work by Kalai and Kalai (2010) for an important subset of the protocols we study. The analysis is potentially important in many real-world contexts, such as collective bargaining and many kinds of bilateral bargaining situations in business and politics. The focus of the experiments is familiar game of bilateral trade with two-sided incomplete information (Chatterjee and Samuelson (1983), Myerson and Satterthwaite (1983)). The results of the experiment show that the option of the sort of formal partnership protocol proposed by Kalai and Kalai can increase the proportion of available surplus captured by traders. The simple option of cheap talk, however, can sometimes increase efficiency. We begin, though, in section 2, with an illustration of the essential idea contained in Kalai and Kalai (2010), as the idea is quite general and, we believe, powerful. Section 3 contains details of the experimental design and procedures. Section 4 contains results, and Section 5 concludes. An appendix contains the instructions for one of the experimental treatments.

2. Partnership Protocols

Consider the standard prisoners' dilemma, which can be illustrated as follows:

PRISONERS' DILEMMA	Not Rat	Rat
Not Rat	100, 100	0, 150
Rat	150, 0	1, 1

The row player can either "Not Rat" or "Rat" and same for the column player, where "Not Rat" means not confessing your guilt and also implicating the other player, while "Rat" means confessing. If neither player rats out the other player, then both do well with a payoff of 100. But the payoff to each player is better playing Rat than Not Rat. If you rat out your partner, then you get a good payoff of 150 and your partner gets 0. Since the strategy Rat is a dominant strategy for each player, (Rat, Rat) is the unique Nash equilibrium for the game, and the players get a payoff of 1 each in this equilibrium.

This game perfectly illustrates the issues mentioned at the outset. The Nash equilibrium of this game is wildly wasteful. Payoffs 100 times larger for both players are available, but evidently are not enforceable as an equilibrium of the game. If one player believes the other will Not Rat, then it is in his or her interest to Rat. Would real players in a game with real payoffs (say, in dollars) actually both Rat out the other player? Experimental studies show mixed results. The unique Nash equilibrium is surely not the unique behavioral outcome. Many players will attempt to achieve the cooperative outcome in early trials (i.e., (Not Rat, Not Rat)), but more play will tend to be non-cooperative (Rat-ing) in later trials, for randomly matched subjects (i.e., in each trial players are randomly re-matched. The analysis here does not apply to repeated play between the same two players).

We now illustrate the two main *partnership protocols* (the term comes from Kalai and Kalai (2010)) that we propose to study, for the prisoners' dilemma. The first is simply to allow subjects to discuss the situation prior to making their decisions. This is not the same as making a binding commitment, which would, obviously, solve the problem and make it easy for players to achieve the efficient solution where each gets a payoff of 100. The question is whether such "cheap talk," which does not guarantee that the other player will do as he or she says, is sufficient to achieve the efficient outcome. Recent work in other contexts suggests that such talk may be effective. For example, Isgin (2011) studies the following labor market situation in the laboratory. Employers make wage offers that employees may accept. Upon accepting an offer, the employee then chooses an effort level. Effort is costly to the employee, but increases the overall profitability of the relationship. She finds that when employers and employees can engage in "cheap talk" (via computer "chat boxes" on the computer screen) prior to contracting, wage levels and effort levels are significantly higher and outcomes are much nearer to the efficient level. There is nothing forcing subjects in these experimental labor markets to do as they say, but nonetheless then tend to do what they say, and they tend to be believed.

This simple kind of partnership protocol may work well in simple games of complete information, such as the prisoners' dilemma, but with games of incomplete information things are much more complicated. Kalai and Kalai (2010) have proposed formal partnership protocols for such games, and our analysis follows directly from their work. I will first illustrate the principles with the prisoners' dilemma, and then discuss the implementation of a protocol for a bilateral exchange game of incomplete information that we study in the experiment.

First, observe that any two person non-cooperative game can be decomposed into two simpler-to-solve games, consisting of a cooperative "team game" with an obvious solution and a competitive zero-sum game, which also has a relatively straightforward solution. The team game is constructed simply by adding up the payoffs in each cell, dividing the total by 2, and giving each player that amount. For the prisoners' dilemma, as above, the corresponding team game is given by:

TEAM GAME	Not Rat	Rat
Not Rat	100, 100	75, 75
Rat	75, 75	1, 1

The obvious solution is to choose the cell with the highest payoffs for both players, and this is self-enforcing—there is no reason to deviate from this solution. The competitive game is constructed by taking the difference between the row and column player payoff, and the difference between the column and row player payoff, in each cell, and dividing each by 2. For the prisoners' dilemma, the corresponding game is given by:

COMPETITIVE GAME	Not Rat	Rat
Not Rat	0, 0	-75, 75
Rat	75, -75	0, 0

Notice that summing up the payoffs in the team game and the competitive game cell by cell gives the original payoff matrix for the prisoners' dilemma. The solution for the competitive game is the "min-max" solution: choose the strategy that will minimize the maximum that your partner can achieve. It also happens to be the Nash equilibrium in this game. The solution is for the row player to choose Rat and for the Column player to choose Rat.

The formal partnership protocol gives the players the choice of opting in. If both players opt in, then the understanding is that they will play the team game and receive payoffs accordingly. They will also, at the time that they choose whether or not to opt in, indicate their strategy choice for the competitive game. If both players opt in, then the competitive game choices will also be implemented for the competitive game. If one or both players do not opt in, then they simply play the original prisoners' dilemma game, using the competitive game strategy choices as the choices for the original game.

While we have motivated this study up to now via a game of complete information, our main interest lies in the study of games of incomplete information. We now outline the analysis of a "double auction," or bilateral trade situation, in which there is one buyer and one seller who may potentially trade at a mutually advantageous price.

This game is much-studied in the literature, both theoretically (Chatterjee and Samuelson (1983), Myerson and Satterthwaite (1983), Matthews and Postlewaite (1989)), and experimentally (Radner and Schotter (1989), Valley, Thompson, Gibbons and Bazerman (2002)), and serves as a good test candidate as it is so familiar to economists, and the situation it represents is likely to be familiar to any experimental subject. We are particularly interested in the interplay, in interpreting the results of experiments, between the non-cooperative equilibria of the game, on the one hand, and the very natural cooperative possibilities that present themselves as soon as some kind of communication is permitted in the game. Although formal analysis of mechanisms (Myerson (1985), Wilson (1985), Hurwicz and Reiter (2006)), particularly with communication (Farrell and Gibbons (1989) (Matthews (2008)), is rather well-developed, the analysis really does not seem to capture the richness of natural communication between agents in bargaining. Part of our aim to is capture what happens, in "black box" fashion, when communication is possible, vs. not possible,vis-à-vis the simplest of solution concepts.

To make things concrete, suppose there is a buyer who has a resale value for the object to be traded of v, and a seller who can produce the object to be traded at a cost of c. If the object is traded at a price p, then the buyer's profit is v-p and the seller's profit is p-c. But this is a game of incomplete information. The buyer's value v lies somewhere in the interval [0,100] and the seller's cost c lies somewhere in the interval [0,100] as well. The agents each learn their own value or cost parameter prior to trading, but the agents do not know the other agent's parameter. If the value and cost parameters are both independently uniformly distributed, then trade is only feasible half of the time. That is, on average, only half of the time will the buyer have a value that exceeds the cost of production, so that it would, in principle, be possible to find a price that lies in between v and c, giving both agents a positive profit.

The mechanics of the game are as follows. The buyer and seller simultaneously submit an offer price, P_o (from the buyer) and an asking price, P_a (from the seller). If $P_o >= P_a$, then trade occurs at the price $(P_o+P_a)/2$. If $P_o < P_a$, then there is no trade, and both players get 0. Theoretical analyses of this game have demonstrated that, although trade is feasible half of the time, it is not possible to ensure that trade occurs whenever it is mutually profitable (Chatterjee and Samuelson (1983) and Myerson and Satterthwaite (1983)). The decomposition outlined above, as well as the simple "talk only" protocol, seems to hold some promise for this game.

Buyers and sellers learn their values prior to trade. In a simple talk-only partnership protocol, the talk could occur either prior to the parties having learned their private information, or subsequent to them having learned their private information. Obviously the degree to which one could verbally commit to some particular action is more limited if discussions occur prior to knowing relevant information. But it would still be possible to speak in general terms about the sort of policy one intends to follow (e.g., a buyer could indicate an intention to offer to pay a fixed amount less than whatever the redemption value turns out to be, or the seller could indicate an intention to ask a fixed amount above the cost of production). Similarly, Kalai and Kalai (2010) have proposed formal partnership protocols for *ex ante* (before values and costs are known) contracting and *interim* contracting (after values are known, but before they are revealed to all). These partnership protocols for the bilateral trade game involve, in the final analysis, each of the parties to agree to report their values (redemption value for the buyer, cost for the seller), with the understanding that the difference between these two, provided the difference is positive, will be divided equally between the two parties. This is the team game. The competitive game would consist in the buyer always offering 0 and the seller always asking for 100. In fact, the competitive game need not be explicitly played, as it is really just an adjustment to payoffs earned in the team game, and can be explicitly explained in that way. However, in asymmetric versions of the bilateral trading game, where one or both parties have other outside options for trading, the competitive part of the game can be non-trivial.

In both cases (ex ante and interim), in order for the mechanisms to work as proposed, it is necessary that both the value and cost is known and revealed to both parties after trade occurs. This is because the formal protocol solutions involve a team game in which the joint proceeds from the partnership, v-c, are shared equally. This *strong revealed payoff* assumption may or may not hold in any given application, of course. In the experiment, it holds by design.

3. Design and Method

In the experiment we study the bilateral trade game using the design illustrated in Figure 1. There are 7 cells in the design, and we have conducted one session of each at this time. The "talk only " protocols are achieved by crossing an environment in which players can only trade (no formal mechanism, a la Kalai and Kalai) with a condition in which there is pre-contracting talk via computer chat boxes. The ex ante and interim distinction is only meaningful in the "Talk prior to trade" column, as players will always have their information prior to actual contracting. The ex ante and interim protocol rows refer to an environment with the formal opt-in choice, executed either prior to or after information is revealed. We have studied both an environment in which only the specifics of the protocol are addressed (the left column) and an environment where free-form discussion is possible prior to consideration of the formal protocols (right column).

<table>
<tr><th colspan="3">Figure 1: Design of Experiment</th></tr>
<tr><td></td><td>No talk</td><td>Talk prior to trade</td></tr>
<tr><td>Trade only, ex ante</td><td rowspan="2">Treatment 1
1 session, 18 subjects,
49 periods</td><td>Treatment 2
1 session, 20 subjects,
29 periods</td></tr>
<tr><td>Trade only, interim</td><td>Treatment 3
1 session, 20 subjects,
30 periods</td></tr>
<tr><td>Ex ante protocol</td><td>Treatment 4
1 session, 20 subjects,
30 periods</td><td>Treatment 6
1 session, 20 subjects,
20 periods</td></tr>
<tr><td>Interim protocol</td><td>Treatment 5
1 session, 14 subjects
50 periods</td><td>Treatment 7
1 session, 20 subjects,
20 periods</td></tr>
</table>

A session refers to a single instance of having a group of subjects in our lab for an experimental session. The lab has a capacity of 20 subjects, and most sessions had 20 subjects, though one session had 18 subjects and another had 14 subjects. In each session subjects were randomly assigned to be a buyer or a seller in each period, and they were also randomly assigned a trade partner in each round, so there was no opportunity for reputation building. All communication (in sessions that allowed it) were conducted via “chat boxes” on the computer screen. Thus, the conversation was sequential, as is natural for communication, and not simultaneous, as in most theoretical analyses of communication in games (e.g., Farrell and Gibbons (1989)). In each session there were at least 20 periods of play. Sessions with communication took longer than those without, so those sessions have more periods. Also, each period of the formal partnership protocol sessions take longer, as there are more steps to take, so those sessions have fewer periods, conditional on the communication conditions (no talk or talk prior to trade). Each sessions lasted about one and a half hours. Earnings ranged between $15 and $45, with the average subject earning about $25, including a $5 payment for showing up on time. Subjects were played for each round of play, and received feedback each round on their earnings for that period. Exchange rates between the laboratory currency (“francs”) and dollars was adjusted by the type of session to keep average earnings approximately constant across sessions. The experiment was conducting using Z-tree (Fischbacher (2007)).

4. Results

Table 1 reports summary statistics for the experiment, broken out by treatment. Table 2 contains results of estimating bid functions for buyers and sellers. . Figures 2-8 show graphically the pairs of buyer and seller offers by treatment. The figures show only those pairs for who trade was feasible (surplus>0). Successful trades are shown in black, unsuccessful trades in red.

Further analysis, yet to be done, includes detailed coding of text communication that occurred in the games to be used as covariates in estimating the probability of successful trade, and the probability of opting in to formal partnership protocols.

Table 1: Summary Statistics

Treatment	Bid (Surplus>0	Ask (Surplus>0)	% Surplus	# Subjects	Periods	% Opt-in
1. Trade-only	48.6	53.0	72.8	18	49	NA
2. Ex ante Trade with talk	50.6	49.9	81.2	20	29	NA
3. Interim Trade with talk	43.4	60.6	70.1	20	30	NA
4. Ex ante protocol, no talk	51.0	47.7	86.6	20	30	61
5. Interim Protocol, no talk	51.7	50.1	82.1	14	50	55
6. Ex ante Protocol with talk	47.3	43.3	89.9	20	20	56
7. Interim Protocol with talk	43.6	56.6	84.1	20	20	47

Table 2: Estimated Bid and Ask Functions

	Treatment 1: Trade Only		Treatment 2: Ex Ante Trade with Talk		Treatment 3: Interim Trade with Talk		Chatterjee-Samuelson Optimal Linear Bid Functions	
	Bid	**Ask**	**Bid**	**Ask**	**Bid**	**Ask**	**Bid**	**Ask**
Own Value Coeff.	.87	.91	.92	.92	.75	.71	.67	.67
z-stat	71.41	84.16	70.99	58.84	34.31	28.92		
	.00	.00	.00	.00	.00	.00		
Other Value Coeff	.00	-.01	-.00	.00	.09	.14		
z-stat	.22	-.48	-.26	.25	4.05	5.84		
prob>z	.82	.63	.80	.79	.00	.00		
Constant	-1.25	11.01	-1.14	8.99	-4.25	21.18	8.33	25
z-stat	-1.27	8.59	-1.13	6.48	-2.47	10.60		
prob>z	.21	.00	.26	.00	.01	.00		
Wald Chi Sq.	5110.55	7107.45	5054.57	3471.96	1194.01	869.38		
Prob> Chi Sq.	.00	.00	.00	.00	.00	.00		
N	441	441	290	290	300	300		
R-sq.	.92	.93	.95	.92	.80	.74		

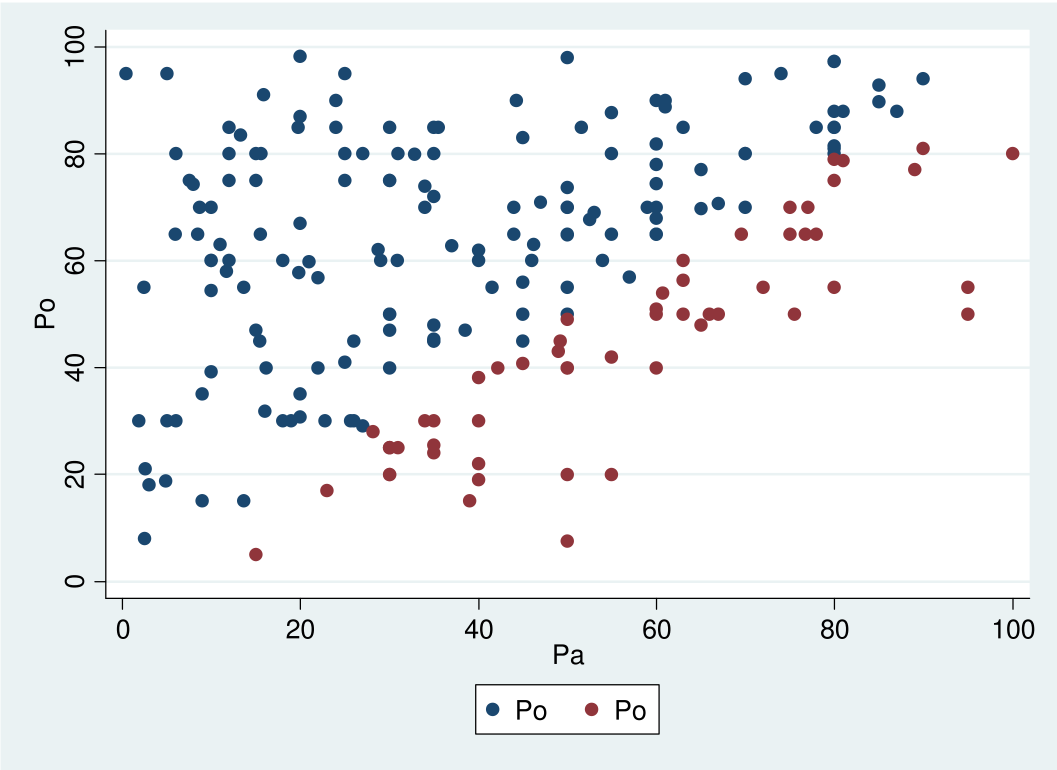

Figure 2: Successful (black) and Unsuccessful (red) trades in Treatment 1, Trade-only, No Talk. Only pairs where trade was feasible are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

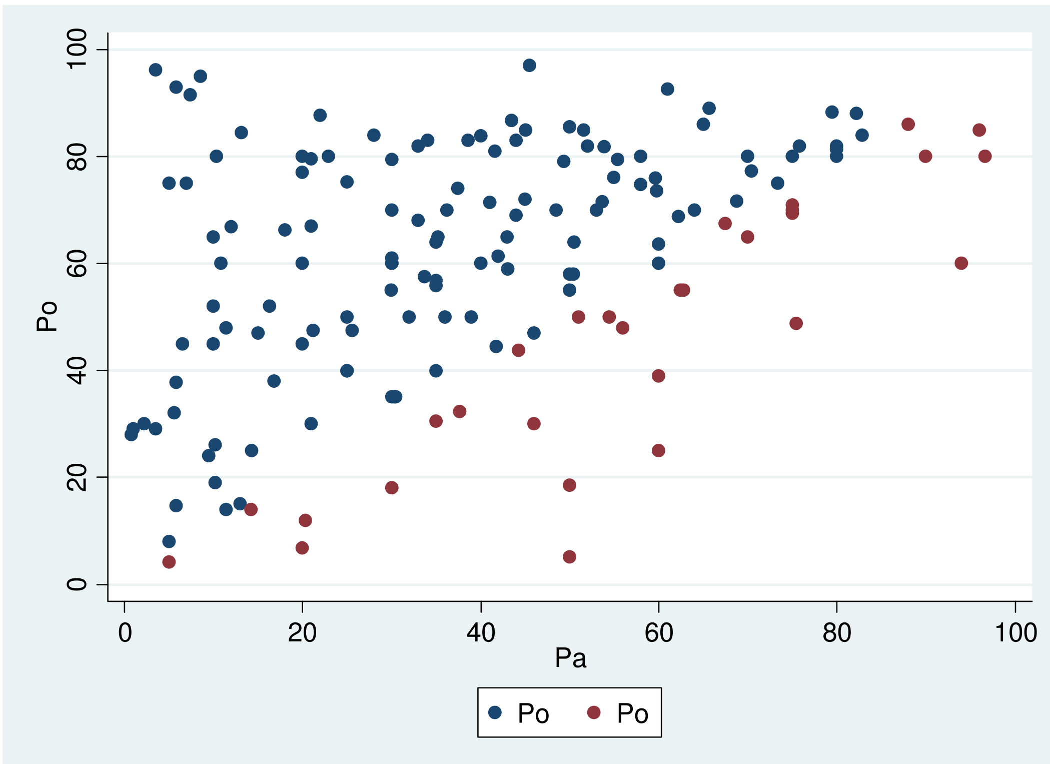

Figure 3: Successful (black) and Unsuccessful (red) trades in Treatment 2, Ex Ante Trade-only with Talk. Only pairs where trade was feasible are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

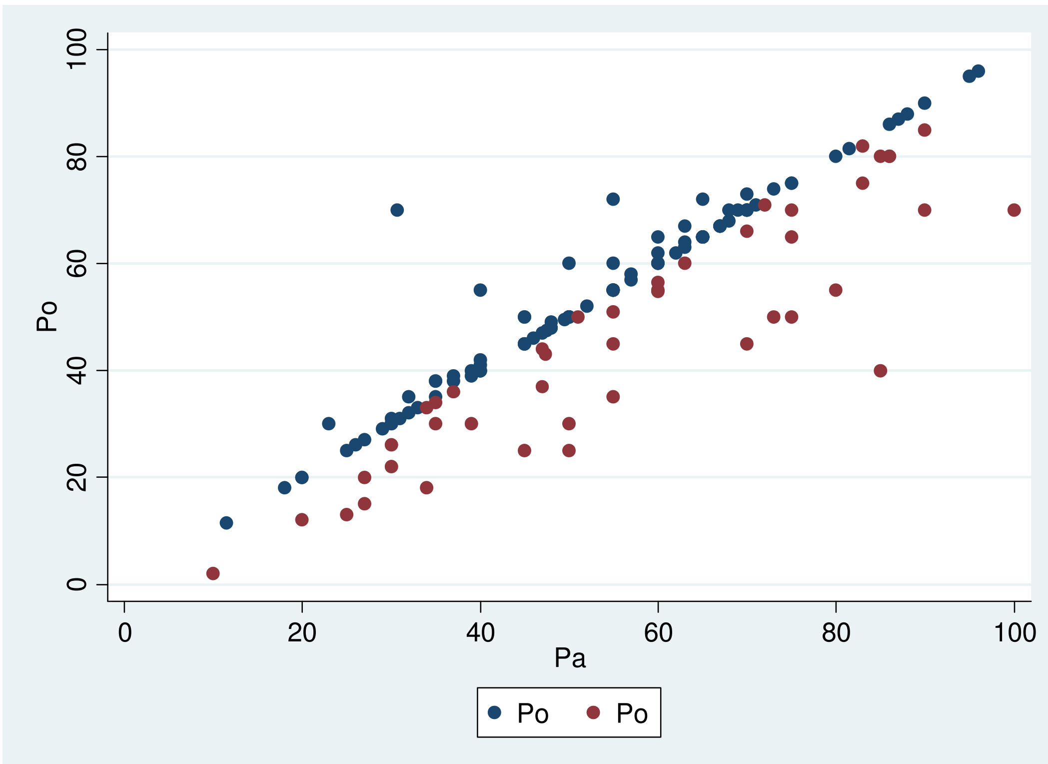

Figure 4: Successful (black) and Unsuccessful (red) trades in Treatment 3, Interim Trade-only with Talk. Only pairs where trade was feasible are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

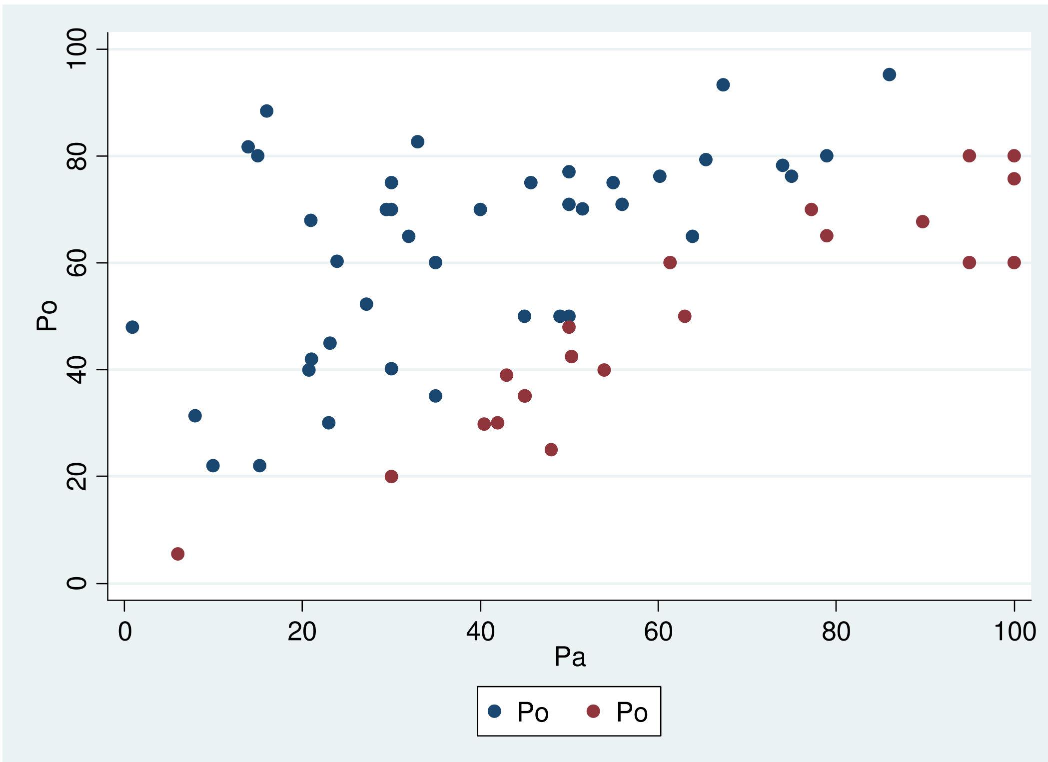

Figure 5: Successful (black) and Unsuccessful (red) trades in Treatment 4, Ex Ante Protocol, no Talk. Only pairs where trade was feasible, and that did not opt into the protocol, are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

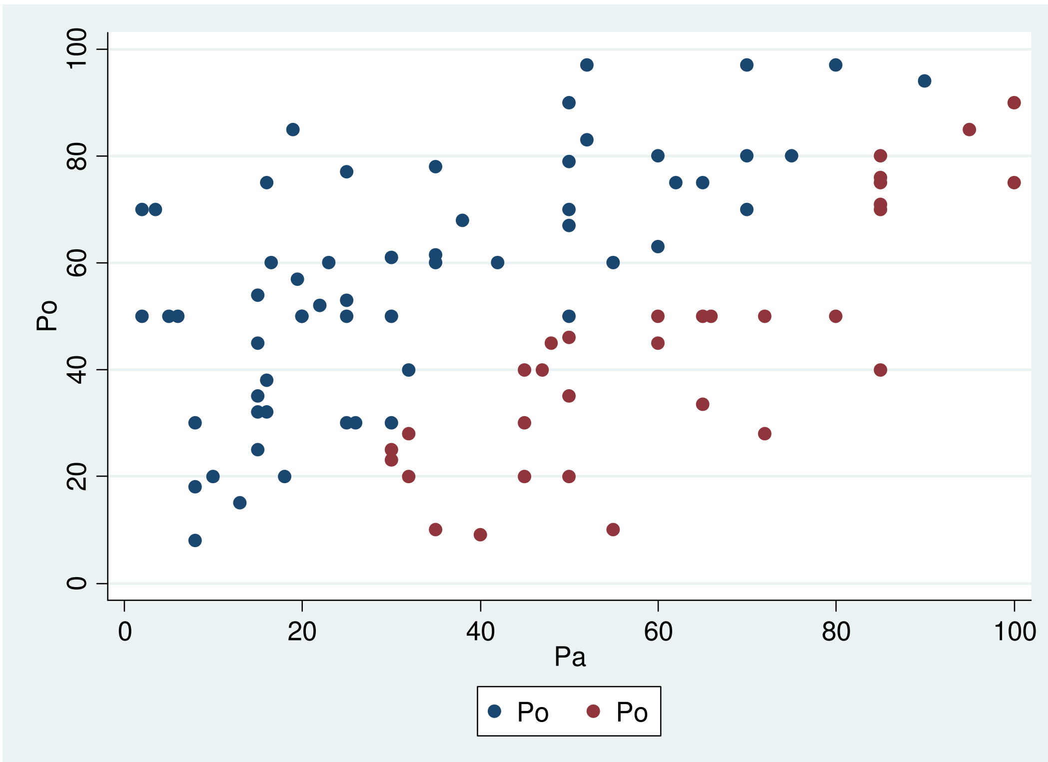

Figure 6: Successful (black) and Unsuccessful (red) trades in Treatment 5, Interim Protocol, no Talk. Only pairs where trade was feasible, and that did not opt into the protocol, are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

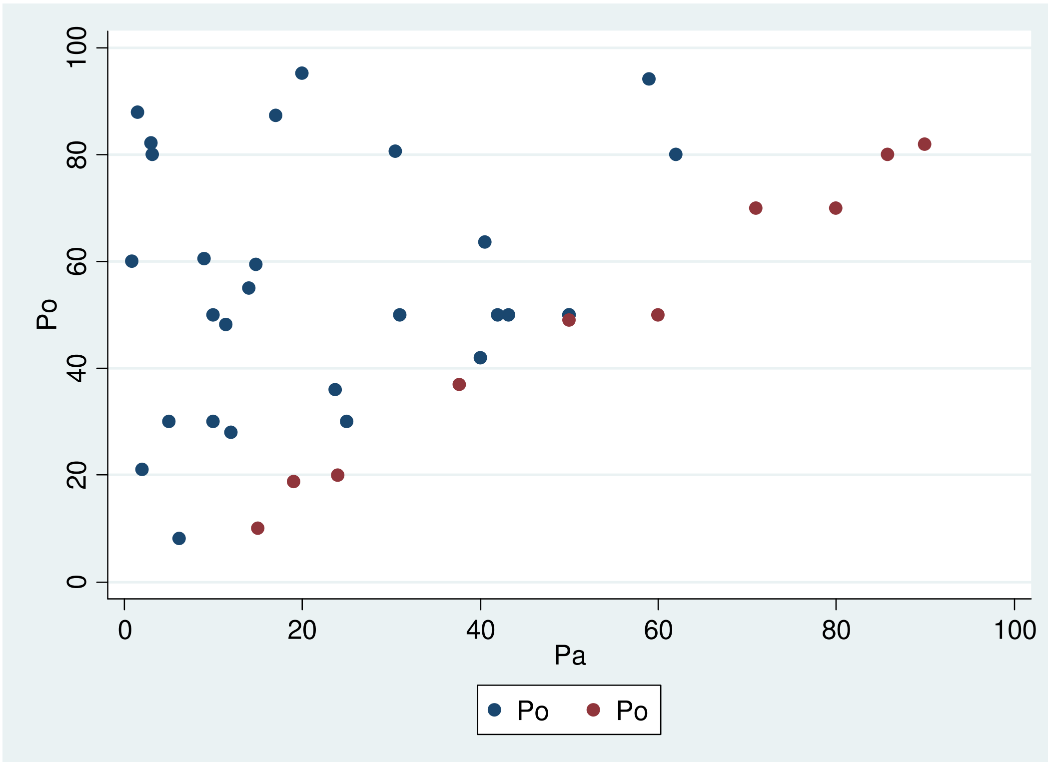

Figure 7: Successful (black) and Unsuccessful (red) trades in Treatment 6, Ex Ante Protocol with Talk. Only pairs where trade was feasible, and that did not opt into the protocol, are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

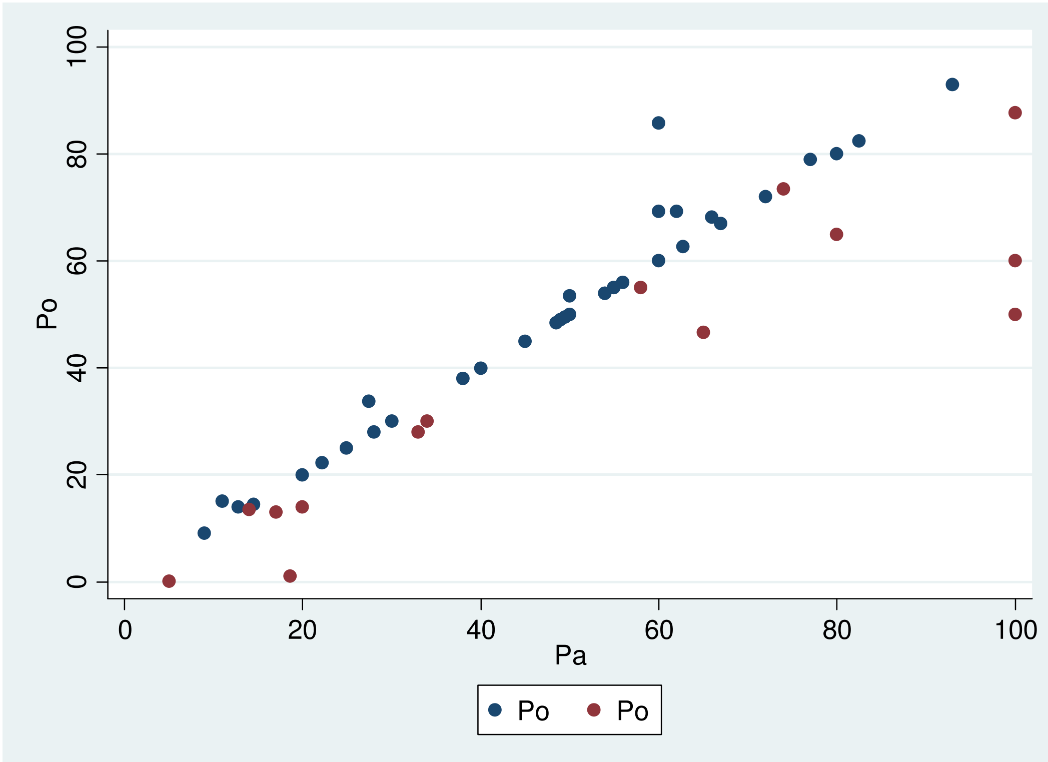

Figure 8: Successful (black) and Unsuccessful (red) trades in Treatment 7, Interim Protocol with Talk. Only pairs where trade was feasible, and that did not opt into the protocol, are shown (surplus>0). Horizontal axis shows seller ask price, vertical axis shows buyer offer price.

5. Discussion and Conclusions

We find substantial evidence that the presence of formal and informal partnership protocols, the former referring to the decomposition proposed by Kalai and Kalai (2010) for two-person games, the latter referring to the simple introduction of cheap talk opportunities prior to trade, can substantially improve efficiency in bilateral trade with incomplete information. Whether the protocol is ex ante or interim matters. Interestingly, when both the formal protocol and cheap talk are available, subjects evidently find that there is a tradeoff between the two. The use of the formal protocols declines somewhat when cheap talk opportunities are available. In the interim cases, when talk is available, successful trade typically involves traders coordinating on a single price—essentially a one-price equilibrium appropriate to the given random draws of value and costs for that period.

Even in those treatments in our experiment where subjects either could not exchange messages (Treatment 1, Trade Only) or could not reveal their values, as they did not yet have them (Treatment 2, Ex Ante Trade with Talk), the buyer bids and seller asks were closer to revealing ("more honest") than the Chatterjee-Samuelson linear equilibrium predicts. As Table 2 shows, the estimated constant terms for both bids and asks are smaller, and the slope coefficients larger, for both Treatments 1 and 2. The estimated functions for Treatment 3, Interim Trade with Talk, are included to show that, unlike Treatments 1 and 2, the other player's value (seller cost for the bid function, buyer value for the ask function) is significant and economically important. These are not meant to be interpreted as equilibrium bid functions, as the behavior subsequent to communication in Treatment 3 is clearly dependent on what is revealed (see Figure 4).

In closing, it is interesting to note that there is a new and growing literature studying bargaining from the neuroeconomics perspective. Some of the results that have been reported seem to be consistent with what we find here. We briefly note the main findings in this literature. Sanfey, et al. (2003), Tomlin, et al. (2006), and Bhatt, et al (2007) have all studied neural responses in the brain during economic exchanges. The Bhatt paper is most relevant in the present context, as they studied a simplified bargaining game that is very similar to that studied in Forsythe, Kennan and Sopher (1991), i.e., a bargaining game with one-sided private information. It is essentially the double auction, but with the seller always having zero cost. In this game, the informed player (the buyer) first suggests a price to the seller, after which the seller chooses a price. If the seller's chosen price exceeds the buyer's suggested price, then trade occurs, as in the double auction. This game allowed the authors to correlate brain activity with behavior of both players. It was found that both *deception,* on the part of buyers, and *suspicion,* on the part of sellers, were both negatively correlated with activity in a part of the brain that is known to be active in other well-studied tasks. The reader is referred to Bhatt, et al (2007) for the details, which are too involved to explain here, but the conclusion they reach is that honesty tends to be a more automatic response, and to deceive or suspect others of deceiving is more costly, in terms of cognitive effort. Thus, the surprisingly high degree of success that subjects in the interim treatments with talk have in coordinating on a single price that we observed is perhaps not so surprising, if you know how the brain works. This may be part of the explanation for why subjects in other experiments give away more information than is optimal, strategically (e.g., "revealing offers" by informed bargainers in Forsythe, et al (1991), and "over-communication" in Cai and Wang (2006), in experimental games based on Crawford and Sobel (1982)). There would also seem to be some scope for accounting for the success of advice given by previous generations of players in achieving outcomes that are sharper, in terms of conforming to equilibrium predictions (Schotter and Sopher (2003, 2006, 2007)), or in selecting Pareto superior equilibria (Chaudhuri, Schotter and Sopher (2009)).

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Appendix: Instructions for Experiment (Ex Ante Trade with Talk)

Introduction

You are about to participate in an experiment in the economics of decision making. Various research foundations have provided the funding for this research. The research is designed to study how people make decisions when facing uncertainty. At the end of the experiment you will be paid for your participation, as outlined in the following instructions.

General Instructions

In this experiment you will have the opportunity to engage in trade with other people in a series of decision rounds. In each round you will be randomly matched with one other person, who is also participating in the experiment. In each round, one member of each pair will be designated as a Buyer and the other person will be designated as a Seller. These designations will be determined randomly. We expect that you will be a Buyer in about half of the rounds and a Seller in about half of the rounds, but as the designations are made randomly, this is only an approximation.

The monetary currency in this experiment is Francs. All transactions will be denominated in Francs. At the end of the experiment, your earnings in Francs will be translated into U.S. Dollars at the rate of $1 for every 100 francs. You will be paid your earnings in cash before leaving the experiment.

Specific Instructions

In each round, each Buyer-Seller pair will make decisions which will determine whether or not a trade will be made. The item that can be traded in each round can be produced by the Seller at a *cost*, C, which is equally likely to be any number of Francs between 0 and 100. The Buyer has a *resale value*, V, for the item, which is also equally likely to be any number of Francs between 0 and 100. The cost, C, to the Seller and the resale value, V, for the buyer, are determined independently at the start of each round. The Seller's cost, C, is his or her own private information and the Buyer's resale value, V, is his or her own private information. That is, the Seller knows the value of C, and the Buyer knows the value of V, but they do not know the other trader's cost or value.

Trading Instructions

In order to make a trade, a Buyer and Seller need to agree on a *price,* P, at which to trade. In each round the Buyer can offer a price to buy, P_o , and the Seller can ask a price to sell, $P_{a..}$ If the Buyer's offer price is at least as high as the Seller's asking price, then trade takes place at a price $P = (P_o + P_a)/2$. That is, trade will take place at the average of the two prices. If the Buyer's offer price is less than the Seller's asking price, then no trade occurs. If a Buyer-Seller pair does not make a trade in a round, the earnings of both the Buyer and the Seller will be zero for that round. If a Buyer-Seller pair does make a trade, then the earnings of the Buyer and the Seller in that round are determined as follows:

Buyer's Profit = Resale Value – Price paid for item = V – P.
Seller's Profit = Price received for item - Cost = P – C.

Notice that the Buyer will make positive profits provided the resale value, V, is bigger than the price paid, P. Similarly, the Seller will make positive profits provided the price received, P, is bigger than the cost of production, C. The trading program will not allow the Buyer to offer a price higher than the resale value, V, and it will not allow the Seller to ask a price lower than the production cost, C.

At the end of each trading period both the Buyer and the Seller in each pair will be informed of the earnings of the other trader in the pair. If trade has occurred, the traders will be able to determine what the cost or resale value of the other trader was. Otherwise, if no trade has occurred, the traders will not be able to determine what the other trader's cost or resale value was, since they will only learn that their own and the other trader's profits were zero in that round.

Notice that it is only possible for traders to earn positive profits if the Buyer's resale value, V, exceeds the Seller's production cost, C. Furthermore, it is also necessary that the Buyer's offer price not be lower than the Seller's asking price or, equivalently, that the Seller's asking price not exceed the Buyer's offer price, for otherwise trade cannot occur.

Alternative Optional Trading Procedure: The Partnership Protocol

The Trading Instructions above describe the usual way for a Buyer and a Seller to try to come to an agreement on a price at which to transact a trade and earn profits. There is a second way that they can try to accomplish an agreement, known as a *partnership protocol.* Both the Buyer and Seller in each pair will have the option to enter a partnership protocol at the start of each round, prior to each trader learning his or her private information (the resale value, V or the production cost, C). If one or both traders decline to enter the partnership protocol, then the procedures described in the Trading Instructions above will be followed. If both traders opt to enter the partnership protocol, then they will proceed as follows instead. First, both traders will learn their private information (V for the Buyer, C for the Seller). Then each trader will make a report of their private information, V_r for the Buyer and C_r for the Seller. The only limitation on these reports is that the Buyer's reported value cannot be larger than the true value, V, and the Seller's reported cost cannot be smaller than the actual cost, C. These reports will then be simultaneously transmitted to the other trader, so that each trader will have the other trader's report of his or her information. If V_r is larger than C_r then a transaction will take place and the traders will each receive profits equal to $(V_r - C_r)/2$. That is, the Buyer and Seller will equally share the difference between the Buyer's reported value and the Seller's reported cost. If the reported resale value, V_r is less than the reported production cost, C_r then there is no transaction and both traders earn zero profits.

Notice that the total of the Buyer's and the Seller's profits in a successful Partnership Protocol transaction will equal the total profits that would be achieved under the usual Trading Instructions for a successful transaction, provided the Buyer and Seller truthfully report their information. Misreporting information will only reduce the traders' profits, it can never increase profits.

Notice also that there will always be a transaction in a Partnership Protocol, provided the reported resale value, V_r , exceeds the reported production cost, C_r. Under the usual Trading Instructions, there will only be a successful transaction if the offer price, P_o, is at least as high as the asking price, P_a, as well.

Communication

Both traders will have the opportunity to communicate with each other prior to making decisions about entering a partnership protocol. Prior to learning their private information, the Buyer and the Seller will be able to communicate via a "Chat Room" by exchanging typed messages. You may communicate any information you like, except that you may not reveal your identity or make physical threats. At the end of the communication period, which is 60 seconds, the traders will proceed with trade as outlined above.

Summary

In the experiment you will be randomly paired with another person in each trading round. In each round you will be randomly designated as either a Buyer or a Seller. You will make decisions and earn profits to the extent that you are able to arrive at a successful transaction. Whether you are successful in earning profits in each round will depend both upon the decisions that you and the person you are paired with make, and upon the randomly determined resale value and production cost for your pair in that round. In some rounds, these values will be such that no profitable trades are possible. In other rounds, profitable trades will be possible.

Your total profits over all of the trading rounds will be converted into U.S. Dollars at the rate of $1 for every 100 francs. You will be paid your earnings in cash before you leave the experiment.