Dissolving Partnerships Under Risk: An Experimental Investigation*

Kyle Hyndman†

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Abstract

We experimentally study a situation in which two players negotiate the dissolution of a risky partnership. In our experiments, subjects must simultaneously negotiate both a selling price and the identity of the buyer. Upon reaching an agreement, one party (the buyer) will be subject to ex post risk, while the other party (the seller) will not, and the negotiation determines which party will hold the risk. Our results show that buyers extract a premium which is increasing in the riskiness of the partnership value distribution. Moreover, during bargaining, the majority of subjects make offers in which they would be the buyer (and thus exposed to risk) if the offer is accepted. Allowing subjects to communicate has noticeable effects: agreements are significantly more frequent and sorting according to fairness ideas – such that the buyer is the player with the higher "fair price" – is more frequent. We also show that, when subjects are able to communicate, bargaining pairs who discuss risk exposure or fairness generally agree to a lower price, giving greater compensation to risk for the buyer.

JEL classification codes: C71, C92, D81

Keywords: Bargaining, Ex-post Risk, Partnership Dissolution

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†Naveen Jindal School of Management, University of Texas at Dallas, 800 W. Campbell Rd (SM31), Richardson, TX 75080 (E-mail: KyleB.Hyndman@utdallas.edu).

1 Introduction

Partnerships represent an important part of our business (e.g., joint ventures) and social (e.g., marriages) fabric. Yet, it goes without saying that not all partnerships are ultimately successful. For example, numerous studies have shown that about 50% of partnerships are dissolved (Coopers and Lybrand, 1986; Bamford et al., 2004; Anderson and Jap, 2005; KPMG, 2009) and almost half of first-time marriages eventually end in divorce (Aughinbaugh et al., 2013).

Given the importance of partnerships to our economic and social lives, and given that they often end in failure, considerable attention has been devoted to the topic by economic theorists starting with the seminal paper of Cramton et al. (1987), who took a mechanism design approach to understand how to efficiently dissolve a partnership when the underlying valuations of partners were private information. McAfee (1992) considered a similar setting but restricted attention to "simpler" mechanisms such as first and second price auctions and the buy-sell clause, in which one partner proposes a price and the other partner decides whether she would like to buy or sell at that price.[1] As shown by McAfee (1992), the buy-and-sell clause may lead to an inefficient allocation wherein the partnership may not be purchased by the partner who values it most. In part, this is because the buy-sell clause often exogenously specifies the roles of the partners as either the proposer or the chooser. de Frutos and Kittsteiner (2008) suggested that negotiation over the right to choose who gets to make the offer could be one way to dissolve partnership in an ex post efficient manner.[2]

Much of the theoretical literature cited above, as well as the experiments conducted that relate to partnership dissolution (e.g., Kittsteiner et al., 2012; Qin and Zhang, 2013; Landeo and Spier, 2013, 2014; Brown and Velez, 2016) involve situations in which the partners have different, and private, valuations for the underlying partnership. While this is important and relevant, we are interested in another aspect of partnerships. In particular, they are often risky. For example, a restaurant's underlying future business prospects are highly uncertain. Therefore, dissolving a restaurant partnership means that the buyer obtains a risky asset and the seller receives a fixed, riskless, payment. As another example, for a couple divorcing, while financial assets may be easily divisible, a house is not and, moreover, the home's resale value is subject to uncertainty.

In this paper, we are interested in the joint problem of how partners can simultaneously decide on a price and an allocation of an indivisible risk – that is, who will be the buyer of a risky asset and what price will they pay to the seller. White (2006, 2008) has theoretically studied the issue of bargaining with asymmetric exposure to risk for the case in which the risk holder is exogenously specified before bargaining. She showed, unsurprisingly, that the party exposed to risk will typically receive a risk premium. More surprisingly, she also provided conditions under which the exposed

[1] See also Jehiel and Pauzner (2006) and Segal and Whinston (2012) for another economic treatment and Ayres and Talley (1995) for a more legal approach which touches on partnership dissolution.

[2] In contrast to our paper where the value is the same (but risky) to both partners, in de Frutos and Kittsteiner (2008), each partner has a privately known value, v_i which are drawn independently from a commonly known distribution. Thus, ex post efficiency in their paper is that the buyer is the partner who values it most highly, while in our paper, efficiency is that the less risk averse partner is the buyer.

agent may actually prefer to bargain over a risky pie-distribution. Experimentally, for the case in which the risk holder is exogenously specified, Embrey et al. (2021) verified that exposed agents receive a risk premium and that it can be large enough that these exposed agents benefit from risk. However, they showed that the conditions under which this happens are markedly different from White's theory (in that it is the comparatively less risk averse residual claimants who benefit, while White's theory predicts the opposite). We will show a related result in that a majority of the players in our experiment – through their offers – reveal a preference to be the one to bear the risk.

In a supply-chain setting, Davis and Hyndman (2019) showed that (inventory) risk holders typically suffered in the negotiations and, when the allocation of risk was endogenous, most players tried to avoid holding risk. They argued that this was, in part, due to an anchoring bias in bargaining which arose because of the way in which the size and division of the pie was determined.[3] Our setting is simpler in that the size of the pie is exogenously given and players only have to negotiate over the division of the pie and who will bear the risk. As noted above, and shown below, in our simpler bargaining setting, a majority of players prefer to bear the risk.

In our experiment, subjects are co-equal owners in a partnership that must be dissolved. The business is worth $\$20+X$, where X is a random variable taking value $\pm\mu > 0$ with equal probability. The players are then given time to negotiate in an unstructured fashion over two dimensions: (i) the identity of the buyer and the seller and (ii) a price, p, that the buyer pays to the seller for his/her share. The seller's payment is, therefore, fixed while the buyer's payoff is subject to risk. Within the same experimental session, we vary the riskiness of the pie-distribution. We also consider two between-subjects variations: one in which players can only exchange offers and another in which subjects can engage in chat-box communication during bargaining.

With this design, we are able to test some key predictions from the Nash bargaining solution. Namely, whether the price for the business decreases as risk increases, and whether there is efficient sorting due to risk preferences. Specifically, as we will show, if the players' risk preferences are sufficiently close, then the Nash bargaining solution randomizes over the identity of the buyer. The reason is, when risk preferences are close, the Pareto frontiers of two fictitious Nash bargaining problems (one where each player commits to buying) intersect, which creates a region where the frontier can be expanded by randomizing over who buys. However, as soon as the players' risk preferences are far enough apart, then the less risk-averse player should be the one to buy. We are also able to test whether communication increases the likelihood of efficient sorting according to risk preferences.

Our results show that the price is, indeed, decreasing as the pie-distribution becomes more risky. Thus, buyers do get increasing compensation for their increased risk exposure. Interestingly, this compensation is of a comparable magnitude to that reported in Embrey et al. (2021) for the case of exogenous exposure to risk. We also show that there is some sorting into buyer/seller roles

[3]Specifically, in the supply chain setting, players negotiated over a wholesale price (i.e., a price paid by, say, a retailer to a supplier) and an order quantity. The order quantity determines the size of the pie, while the wholesale price determines the division of the pie. Davis and Hyndman (2019) showed that players anchored on a wholesale price that seemed fair in that it split the difference between the supplier's cost and the retailer's selling price, but failed to adequately adjust for the asymmetric exposure to risk.

according to risk preferences, particularly when the differences in risk preferences are especially large. However, the sorting that does occur is much less than the underlying theory would predict. In fact, we show that most players appear to prefer to be the buyer – revealing that the lower price that they pay is sufficient to compensate them for their risk exposure.

Our results on communication are somewhat mixed. Consistent with previous results in the bargaining literature, communication appears to increase the frequency of agreement, but it does not increase the frequency of efficient sorting according to risk preferences. It does, however, increase the frequency of sorting based on fairness ideas. As we discuss below, we elicited subjects' idea of a "fair price" for the partnership. In general, there is some evidence that the buyer is more likely to be the player with the higher "fair price", and this is further enhanced when communication is possible. Our analysis of the chat messages show that bargaining pairs frequently talk about the underlying risk exposure of being the buyer as well as concerns about the fairness of proposals. We also show that the final, agreed upon, price is significantly lower when either risk, fairness or both are discussed during the negotiation than when neither are mentioned.

In the next section, we provide details on our experimental design, provide a brief theoretical analysis based on the Nash bargaining solution and derive our hypotheses. In Section 3 we provide our main experimental results, while Section 4 discusses in more detail the effect of communication on outcomes. Finally, Section 5 concludes.

2 Experimental Design, Theory and Hypotheses

2.1 Experimental Design

All of our experiments took place at the Laboratory for Experimental Operations and Economics at the University of Texas at Dallas in February and September 2016. In total, we conducted 12 sessions and each session had 12 subjects. The experiment consisted of two treatments – 6 sessions of each – which differed based on whether chat communication was allowed during bargaining or not. Each session was divided into three parts: the main bargaining experiment, a risk elicitation experiment and a post-experiment survey. Subjects were told that there would be an additional experiment after the bargaining experiment, but they were not given details about it until the after the completion of the bargaining experiment. In total, 144 subjects participated and earnings averaged \$19.18 (min. \$4.27; max. \$37.00). All sessions took less than 90 minutes to complete and were conducted in zTree (Fischbacher, 2007).

We now describe the structure of each bargaining period in our experiment. In total there were 9 bargaining periods. In each period, subjects were matched into pairs. In each subsequent period, subjects were rematched in such a way that they would never interact with the same player twice.

In each period, subjects were told in the instructions (available in Appendix B) that they, and their match, were equal owners of a partnership that now needed to be dissolved. They would then have four minutes to negotiate the dissolution of the partnership. There were two parameters that needed to be agreed upon. First, they had to determine a purchase price for one of the subject's share of the partnership. Second, they had to determine which of the two players would purchase the partnership from the other. Owning the partnership was risky. In particular, the gross payoff to the player who bought the partnership was either $\pi - \mu$ or $\pi + \mu$, with each value being equally likely; and, in the experiment, $\pi = \$20$. That is, owning the partnership had an expected value of \$20, but it was risky. In the experiment, we varied the level of risk; specifically, $\mu \in \{4, 6, 8\}$, with each value occurring in three periods. At the time of bargaining, it was common knowledge what the value of μ was.

If the players reached an agreement, then the person who purchased the other's share of the partnership received either $\$20 + \mu - p$ or $\$20 - \mu - p$, where μ captures the riskiness of the partnership and p is the agreed upon price. On the other hand, the person who sold their share of the partnership would receive the agreed upon price, p. This creates an asymmetry because the buyer's payoff is subject to risk, while the seller's payoff is not. If the players did not agree within the four minute time limit, then they both received nothing for that period.

At the end of the nine bargaining periods one period was selected at random for payment. After this, subjects completed an incentivized risk elicitation task in which they had to report several certainty equivalents for various lotteries, one of which would be randomly selected to count for an additional payment. To make the risk elicitation similar to the main experimental bargaining task, the elicitation was framed as the price at which they would be willing to sell a specified binary lottery. An example screenshot from this exercise can be found in Appendix C. With this risk elicitation, we estimated subjects' risk preferences, assuming CRRA utility of the form, $u(x) = \frac{1}{1-\rho}x^{1-\rho}$, where $\rho > 0$ indicates risk aversion and $\rho = 0$ denoting risk neutrality. One subject was estimated to be risk seeking, four others were estimated to be approximately risk neutral with $|\rho| < 0.1$, while the other 139 subjects displayed some degree of risk aversion. The median risk coefficient was approximately 0.467 and the 25th and 75th percentiles were approximately 0.32 and 0.56.[4]

In the survey, we asked subjects to report their fairness ideas regarding a fair purchase price. Specifically, for each pie-distribution, indexed by $\mu \in \{4, 6, 8\}$, we asked, "Suppose that the partnership is either worth $20 - \mu$ or $20 + \mu$ with equal probability. In your opinion, what would be a 'fair' purchase price?" This elicitation was not incentivized.

2.2 Theoretical Analysis

Since bargaining is unstructured, we are motivated to look at the Nash bargaining solution.[5] We will focus our attention on CRRA utility. Suppose that player i buys player j's share at price p. We suppose that the value of owning the partnership is distributed according to $\pi \pm \mu$, with equal

[4] As a comparison to the literature, our subjects are somewhat more risk averse than in Embrey et al. (2021), but both the subject pool differed as well as the elicitation method.

[5] Note, in particular, that we are assuming common knowledge of risk preferences. While Myerson (1984a,b) has made progress by defining an extension of the Nash bargaining solution to the case of incomplete information, Embrey et al. (2021) show that it is exceedingly difficult to make theoretical progress in a model with asymmetric exposure to ex post risk (though, as noted elsewhere, simpler than the current setting in which the risk holder is exogenously given). Moreover, we follow recent experimental papers (e.g., Bolton and Karagözoğlu (2016)) who implement an unstructured bargaining protocol while using the Nash bargaining solution based on common knowledge of risk preferences in order to generate predictions.

probability, where $\mu > 0$ captures the riskiness of owning the partnership. In this case, the utility of each player is given by:

$$\begin{aligned} u_{i,b}(p) &= \frac{1}{2(1-\rho_i)}\left((\pi+\mu-p)^{1-\rho_i} + (\pi-\mu-p)^{1-\rho_i}\right) \\ u_{j,s}(p) &= \frac{1}{1-\rho_j} p^{1-\rho_j}. \end{aligned}$$

As we vary p, we can construct the Pareto frontiers under the assumption that player 1 buys, and under the assumption that player 2 buys. In Figure 1, we carry out this exercise for two different sets of risk parameters. In panel (a), the players have identical risk preferences, while in panel (b), player 2 is more risk averse than player 1. The solid line represents the case where player 1 commits to buying, while the dashed line represents the case in which player 2 commits to buying. The dot on each frontier represents the Nash bargaining solution under the relevant assumption on which player buys. Panel (c) presents the same information as in panel (a) but zooms in on the relevant region surrounding the two Nash bargaining solutions where player 1 or player 2 commits to buying, and also including (black dot beyond the Pareto frontiers) the Nash product when ownership is randomized.

First, observe that in both cases, if players could commit to a course of action, they would commit to being the buyer. This is true even for player 2 when he is strictly more risk averse than player 1. However, such a commitment is not credible for player 2 when he is significantly more risk averse. As can be seen in panel (b), there is a region in which player 1 buys which Pareto dominates the Nash bargaining solution in which player 2 buys. On the other hand, such a commitment by player 1 would be credible since, when she is strictly less risk averse than player 2, no allocation in which player 2 buys would yield a Pareto superior outcome to the Nash bargaining solution when player 1 buys.

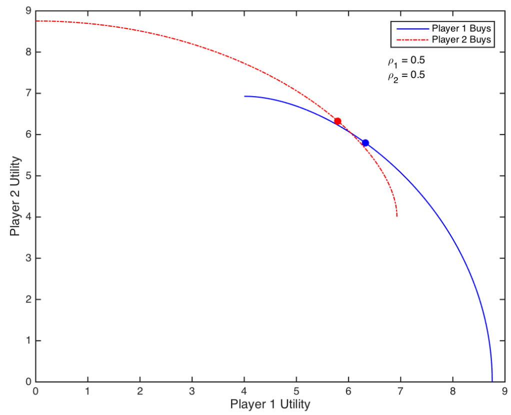
Although both players would prefer to buy, we see that when the difference in risk aversion is large between players 1 and 2, the more risk averse player only benefits by a relatively small amount from buying, while the less risk averse player benefits much more substantially from being the buyer. Therefore, while we would expect the less risk averse player to be the buyer, it should be much more likely to occur the larger is the difference in risk aversion — the less risk averse subject has much more to fight for, while the more risk averse person has much less to fight for. When both subjects have identical risk preferences, then we should expect them to essentially randomize which party is the buyer.

Of course, this intuition can be formalized. Specifically, since the identity of the buyer is part of the negotiation, it makes sense to include this in the calculations for the Nash bargaining solution. Denote by $\lambda_i \in [0,1]$ the probability that player i is the buyer, where $\lambda_1 + \lambda_2 = 1$. Then, the expected utility of player i is then:

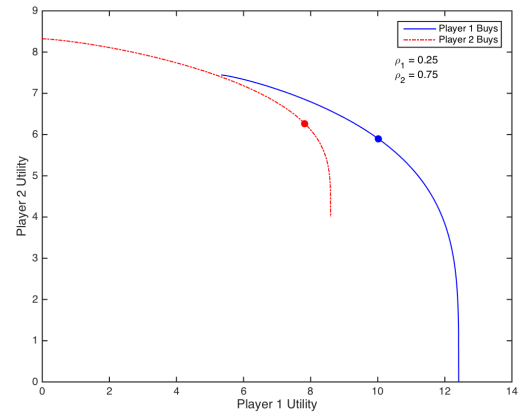
$$U_i(p,\lambda_i) = \frac{1}{1-\rho_i}\left(\lambda_i(0.5(\pi+\mu-p)^{1-\rho_i} + 0.5(\pi-\mu-p)^{1-\rho_o}) + (1-\lambda_i)p^{1-\rho_i}\right).$$

Figure 1: Pareto Frontiers When Player 1 or Player 2 Commit to Buying

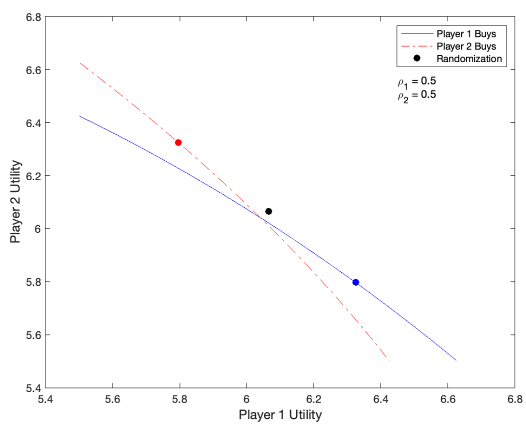
(a) Identical Risk Preferences



(b) Player 2 is More Risk Averse



(c) Identical Risk Preferences: Zoomed-In



Note: In each plot, the dots represent the Nash bargaining solution for the relevant case in which one player commits to buying. Panel (c) is for the same parameter set as (a) but zoomed-in on the relevant region. It also shows the Nash product for the case of equal randomization.

We can then solve for the Nash bargaining solution by solving:

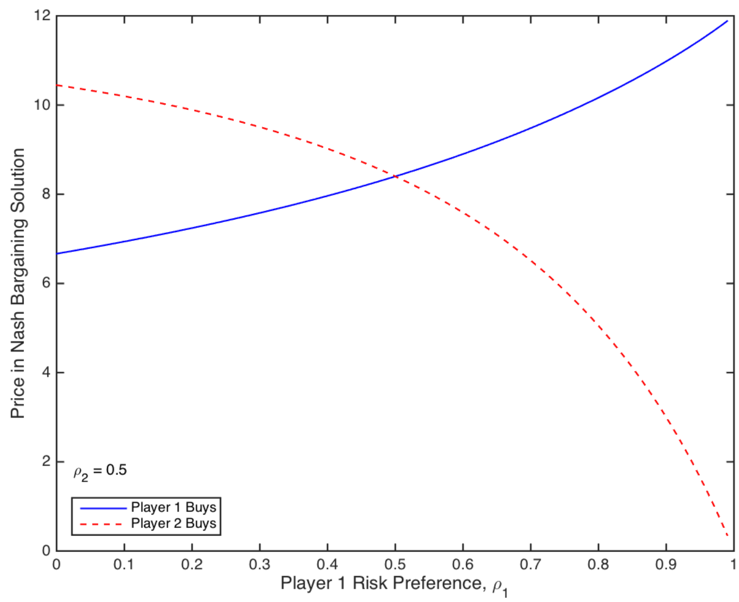
$$\begin{aligned} \max_{p,\lambda_1} \quad & U_1 U_2 \\ s.t. \quad & 0 \leq p \leq \pi - \mu \\ & 0 \leq \lambda_1 \leq 1 \\ & \lambda_2 = 1 - \lambda_1 \end{aligned}$$

Analytical solutions are difficult to obtain, but some intuition is possible. Consider the case of Figure 1(a)/(c) in which players have identical risk preferences. By randomizing who is the buyer, while keeping the price fixed, it can easily be seen that this will lead to a higher Nash product than the case in which either player is the buyer for sure (the black dot in panel (c) beyond the frontiers when either player commits to buying).[6] In fact, as we show in the appendix, with identical risk preferences, both players get an equal chance to be the buyer. From a strictly utilitarian point of view, because both players are risk averse, the best thing would be for both players to share the risk equally. Given that this solution is not available, the best that the players can achieve is to randomize over the identity of the buyer and "share" the risk that way. That is, the best-case scenario is for the players to each take 50% of the risk 100% of the time (however, this is not implementable because of the need to dissolve the partnership); the next-best alternative is for each player to take 100% of the risk 50% of the time; and the worst option is for one player to take 100% of the risk 100% of the time. In the appendix, we formally prove that when players have identical, risk-averse, preferences then an equal randomization over the identity of the buyer generates a strictly higher Nash product than when one player buys for sure.

As player 2 becomes more risk averse, the frontiers shift such that the solid line rises relative to the dashed line (as can be seen by comparing Figures 1(a)/(c) and 1(b)). As long as the risk preferences are not too different, it is possible to find a price and a probability (greater than 50%) of player 1 being the buyer which generates a higher Nash product. This is because, when risk preferences are not too different, there are efficiency gains to sharing the risk by continuing to randomize over the identity of the buyer. However, eventually the risk preferences become too extreme and the Nash product is maximized when player 1 is guaranteed to be the buyer. When player 1 is more risk averse than player 2 the situation is reversed. As long as risk preferences are not too different, then player 1 will buy with some probability less than 50%. However, eventually, as the difference in risk aversion increases, then player 2 will buy with certainty. As we argue in the appendix, because randomization over the identity of the buyer is *strictly* optimal for the case of identical risk preferences, the underlying continuity of the problem guarantees that there is a range of unequal risk preferences for which randomization remains optimal even if, counterintuitively, this means that's the *more* risk averse player buys with strictly positive probability. However, numerical calculations suggest that, for the CRRA risk preferences and type of risks that we consider, this

[6] In Lemma 3 in the appendix, we formalize this and show that when risk preferences are identical, there does not exist an alternate price and allocation such that one player buys for sure that Pareto dominates the utilities achieved in the Nash product with equal randomization. Moreover, the logic of the proof is not strongly tied to the CRRA assumption and can be expected to hold more broadly.

Figure 2: The Effect of Changing Risk Preferences



parameter set is relatively small.

2.3 Hypothesis Development

With the Nash bargaining solution in hand, we can conduct some straightforward comparative statics analyses. First, one can show that, so long as the players are not too risk averse, the price is decreasing as the riskiness of the pie increases. That is,

Hypothesis 1. *As the risk, μ, increases, the price decreases as compensation to the buyer for taking the risk.*

Second, we can ask how the price changes when their risk parameter changes. In Figure 2, we show this relationship (for the simpler case in which the buyer is exogenously given) when player 1 becomes more risk averse, while holding the risk preference of player 2 constant. As can be seen, the usual comparative static holds: more risk aversion for player 1 yields a worse outcome for player 1 (and so a better outcome for player 2). When player 1 is the buyer, the price that player 1 pays to purchase is increasing in player 1's risk aversion. On the other hand, when player 1 is the seller, the price that she receives is decreasing in her risk aversion.

This leads to the following hypothesis:

Hypothesis 2. *Holding fixed the riskiness of the partnership, the price is increasing in the buyer's risk aversion and decreasing in the seller's risk aversion.*

In the appendix, we provide a theoretical foundation for these hypotheses under the assumption of CRRA utility with $\rho_i \in (0, 1)$ and under the assumption that one player commits to being the buyer - which is generally the case, except when the players' risk preferences are very close to each other.[7]

Lastly, from our analysis of the full Nash bargaining solution when we randomize over the identity of the buyer, we have the following hypothesis:

HYPOTHESIS 3. *The likelihood that the less risk averse player buys is increasing in the difference in risk aversion.*

Unfortunately, we are not able to analytically demonstrate this comparative static but the appendix provides a numerical depiction of it. It also shows that, except for a small region around equal risk preferences, the identity of the buyer is deterministically the less risk averse player. That is, when risk preferences are even moderately different, the efficiency gain from allocating the risky partnership to the less risk averse buyer outweighs any benefit of using randomization as a way to "share" the risk between the two players. It is, however, important to point out that it may be hard to empirically support this hypothesis. First, we only observe risk preferences with measurement error. Second, the prediction assumes common knowledge of risk preferences which is unlikely to be satisfied in the experiment and, even if subjects wanted to truthfully report their risk preferences, it may be difficult to determine which player is more risk averse.

Before moving to our results, we also provide a hypothesis on the role of communication. Previous research has shown that communication (either pre-play or during bargaining) improves the efficiency of outcomes (Siegenthaler, 2017; Charness, 2012; Valley et al., 2002), reduces disagreements and leads to more equitable allocations (Gantner et al., 2019; Andreoni and Rao, 2011; Roth, 1995). Most of this literature considers uni-dimensional bargaining (e.g., bargaining over price), while in the present study players bargain over two dimensions – a price and the identity of the buyer. It is, therefore, interesting to examine whether communication is also efficiency enhancing in our setting. Efficiency can be improved in two distinct ways: reducing disagreement and sorting based on risk preferences so that the less risk averse player is the buyer. Thus, we hypothesize the following:

HYPOTHESIS 4. *Allowing players to communicate will (a) reduce the likelihood of disagreement and (b) increase the likelihood that the less risk averse player is the buyer and the more risk averse player is the seller.*

2.3.1 The Importance of Fairness

Since the earliest bargaining experiments (Güth et al., 1982), fairness has been seen as an important driver of bargaining behavior. Later work has provided evidence that subjects typically adopt self-serving notions of what constitutes a fair division (see, e.g., Babcock et al., 1995; Bolton and Karagözoğlu, 2016; Embrey et al., 2021, among others) and then base their bargaining positions on

[7] To be sure, we have not proven these results for more general utility functions; however, we expect Hypotheses 1 and 2 to hold for a wide range of utility function. White (2008) shows that the Hypothesis 1 holds under relatively mild conditions, while Roth and Rothblum (1982) show that increased risk aversion is disadvantageous in bargaining when disagreement is the worst possible outcome, as it is in the present paper (Hypothesis 2).

these fairness ideas.[8] This literature also suggests that when there are competing ideas for what constitutes a fair division of the surplus, the agreements often lie between these competing fairness idea (Gächter and Riedl, 2005; Karagözoğlu and Riedl, 2015; Bolton and Karagözoğlu, 2016).[9] Therefore, it is important to control for fairness ideas when studying an experimental bargaining situation.

Interestingly, however, there is is reason to suspect that fairness ideas may have a reduced role to play in our setting. Recall that Embrey et al. (2021) studies a setting, like ours, except that the buyer and seller are exogenously specified so that they need only negotiate a price. They present strong evidence that the two player roles (buyer and seller) possess very different fairness ideas, with the buyer's fairness idea being significantly lower than the seller's fairness idea. In our setting, where the buyer and seller are endogenously determined, a player contemplating a fair price at which to buy/sell the partnership must consider both sides of the transaction and is, therefore, less likely to express an extreme fairness idea.

Beyond this, consider two players who meet during bargaining, one of whom has a fairness idea of α and the other who has a fairness idea of $\beta > \alpha$. When the identity of the buyer and seller is exogenously given, these fairness ideas represent a source of bargaining tension, particularly when the buyer's fairness idea is α and the seller's is β. In contrast, when the identity of the buyer and seller is endogenous, this actually creates a zone of possible agreement $[\alpha, \beta]$ in which the party with fairness idea α should be happy to sell for any price greater than α, while the party with fairness idea β should be happy to buy for any price less than β.

Lastly, as noted above, communication has been linked to more equitable outcomes (Charness, 2012), which suggests that agreed prices may be closer to fairness ideas in the presence of communication or that sorting buyer/seller roles based on fairness ideas may be facilitated by the presence of communication. Therefore, we conclude with the following:

HYPOTHESIS 5. *Both the agreed price and the identity of the buyer are associated with the fairness ideas of the players, with the buyer more likely to have a higher fairness idea. These relationships are stronger in the presence of communication.*[10]

2.4 Remark on Design

Note that the theory suggests that, when risk preferences are sufficiently close, the players will randomize over the identity of the buyer. In the experiment there was no direct way for subjects to randomize over the identity of the buyer. However, subjects could effectively implement such a randomization device using the fact that they have four minutes to reach an agreement. For

[8] By fairness idea, we mean the price a subject considers fair (after having conducted the division task several times).

[9] See also Birkeland and Tungodden (2014) for a paper which proposes a theoretical model of bargaining with competing fairness ideas.

[10] We are careful not to make strong causal statements here. As pointed out by a referee, fairness ideas may themselves be influenced by the bargaining process and by communication. However, we note that Embrey et al. (2021) showed that fairness ideas were very similar whether elicited before or after the bargaining phase of the experiment.

example, consider the equal risk aversion case and where one player commits to being the buyer. We know that $u_b > u_s$. Therefore, if both players begin negotiations by staking a claim to being a buyer, they know that they could concede immediately and obtain u_s, or they could hold out and hope that the other player concedes, thereby receiving u_b. While there would, undoubtedly, be multiple equilibria of this interaction, one of which would be in mixed strategies, where players concede their desire to be the buyer probabilistically.[11]

3 Results

3.1 Summary Results

In Table 1 we provide some summary statistics for our two treatments.[12] Specifically, for each of the possible value distributions, we report the frequency of agreement, the price agreed conditional on an agreement being reached, the time remaining when the agreement was reached as well as subjects' subjective beliefs about what constitutes a fair price to sell one's share of the partnership.

Table 1: Risk Preference and Bargaining Outcomes

(a) Communication Treatment

Distribution	% Agreements	Price Agreed	Time Remaining	Fair Price
$(16, 24)$	97.22	10.03	103.58	10.02
$(14, 26)$	98.61	9.32	88.80	9.26
$(12, 28)$	96.30	8.82	97.49	8.23

(b) No Communication Treatment

Distribution	% Agreements	Price Agreed	Time Remaining	Fair Price
$(16, 24)$	91.67	9.55	100.60	9.99
$(14, 26)$	94.44	9.51	90.49	9.18
$(12, 28)$	95.37	8.87	97.13	8.10

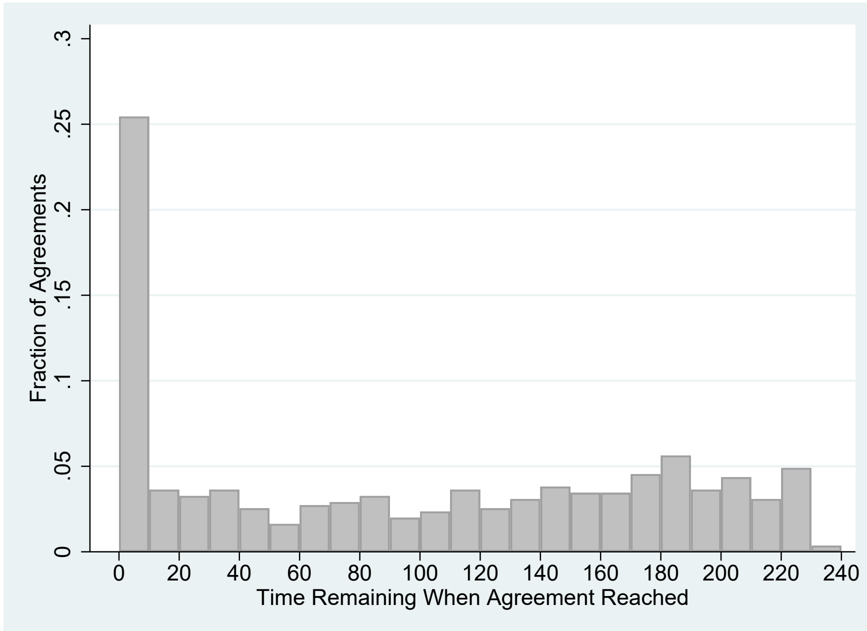
As can be seen, in the vast majority of the cases (97.22% with communication and 93.75% without communication), the pairs are able to reach an agreement. It appears that pairs are more likely to reach an agreement when communication is possible. Though the difference is small in absolute terms (≈3.5 percentage points), it is statistically significant according to both a random effects regression with clustering at the session level ($p = 0.004$) and a Mann-Whitney rank-sum test using session averages ($p = 0.022$) and it also cuts in half inefficiency due to failures to trade.[13]

[11] There would also be two asymmetric pure strategy equilibria in which one player never concedes and the other player always concedes.

[12] In our analysis we drop the first period. In the first period, a substantially higher fraction of transactions occurred in which the selling price was greater than 10, which suggests to us that subjects did not immediately understand the environment.

[13] The random effects regression had the binary variable Agreement as the dependent variable and a dummy for communication.

Figure 3: Histogram of Agreement Time



Thus, as in much of the previous literature, and in support of Hypothesis 4(a), communication facilitates agreements.

From Table 1, we also see that the agreed upon prices are very similar, whether or not communication is allowed. Indeed, neither a random-effects regression, nor a Mann-Whitney rank sum test on session averages are able to reject that the agreed selling prices are the same. Therefore, in our subsequent analysis, we will pool the data between the communication and no communication treatments. Although we will test this formally later, notice also that the selling price decreases as the riskiness of the value distribution increases, and that buyers, on average, receive a risk premium, since the price is generally below half the expected pie size (i.e., 10).

We see that the average agreement is reached with approximately 90 - 100 seconds remaining.[14] However, there is a great deal of heterogeneity as shown in the histogram of agreement times in Figure 3, and there are substantial deadline effects. Fully 26% of agreements are reached within the last 10 seconds and 32.36% of agreements occur in the last 30 seconds.[15] Finally, we also see subjects' subjective views regarding a fair selling price. Except for the least risky distribution, players believe that it is fair for the buyer to pay less than \$10 for full ownership of the partnership, and the fair price decreases as the riskiness increases.

3.2 Detailed Analysis and Hypothesis Testing

In Table 2, we report fixed effects regressions where the dependent variable is the agreed selling price and the various specifications include different sets of control variables, including the elicited

[14]The median agreement time is also very similar.

[15]For comparison, this is somewhat lower than the 41% reported by Roth et al. (1988).

risk parameters and the normalized variance of the distribution, which allow us to test Hypotheses 1 and 2.[16] As can be seen, consistent with Hypothesis 1, there is a significant negative relationship between price and pie-distribution risk: As the distribution becomes more risky, the agreed upon price decreases. Thus compensation for risk increases with the riskiness of the distribution. This is consistent with Embrey et al. (2021) who also show – in a setting where, in our terminology, one player is exogenously determined to be the buyer – that compensation for risk increases as the riskiness of the pie increases. Interestingly, there is no apparent difference in the price when risk allocation is endogenous versus when it is exogenous, as in Embrey et al. (2021). In our case, for example, when the pie-distribution was $(12, 28)$, the price was either 8.82 or 8.87, while Embrey et al. (2021) report a price of 8.86. However, Embrey et al. (2021) saw a disagreement rate of between 8 and 12% when the pie was risky, whereas our disagreement rate was never more than 5.6%.

The second column includes the estimated risk preferences of the party who bought and the party who sold, which allows us to test Hypothesis 2. As can be seen, the more risk averse is the buyer, the higher is the agreed upon price, while the more risk averse is the seller, the lower is the agreed upon price. Both of these effects are of the expected sign according to Hypothesis 2, but neither of them is significant. The third column creates a new variable with the difference between the risk preference of the buyer and the seller. The coefficient is positive, as would be expected, but still not significant.[17] Finally, the fourth column includes the beliefs about fairness for the buyer and the seller. Including these two variables reduces the significance on the coefficient for the variance of the distribution. This suggests that part of the change in compensation for risk is due to changing fairness ideals, rather than risk per se. It is interesting that only the fairness belief of the buyer has a significant effect on the agreed upon price.[18] The main takeaway is that buyers are compensated for risk, and compensation increases with risk. This is due to a direct effect of risk itself as well as an indirect of changing fairness ideals as risk increases. However, we find little support for Hypothesis 2. The selling price is not significantly associated with the risk preferences of the buyer or the seller.

We can summarize this as follows:

RESULT 1. *We find support Hypothesis 1: the price is decreasing in the riskiness of the pie-distribution. However, we find little support for Hypothesis 2; that is, elicited risk coefficients do not significantly impact the agreed upon price.*

[16]Specifically, we normalize the variance so that the riskiest distribution has a variance of 1.

[17]To further test this null result on risk preferences, we also estimated the models separately for those instances where agreement took place with less than or more than 30 seconds left, as the timing of agreement could indicate that players are trying to 'test' their partner's willingness to gamble. There was no effect in either instance. We also defined a more coarse measure of risk aversion – basically whether a player had a risk coefficient above or below the median in the population. Again, this cruder measure did not have a significant influence on the price.

[18]One may be concerned that the fairness ideas were not incentivized and elicited after the experiment. However, Embrey et al. (2021) showed that elicited fairness ideas in their experiment were fairly similar whether or not they were incentivized and whether they were elicited before or after the main bargaining experiment. Because of this, we feel confident that the relationship between fairness ideas and agreements is real. See also, Gächter and Riedl (2005), Karagözoğlu and Riedl (2015) and Bolton and Karagözoğlu (2016) for more experimental results on the role of fairness ideas in bargaining.

Table 2: Fixed-Effects Regression: Determinants of the Selling Price

	(1)		(2)		(3)		(4)	
Variance	-1.246^{***}	(0.291)	-1.231^{***}	(0.304)	-1.231^{***}	(0.304)	-0.698^{**}	(0.268)
ρ^{Buyer}			0.254	(0.777)				
ρ^{Seller}			-0.206	(1.022)				
$\rho^{\text{Buyer}} - \rho^{\text{Seller}}$					0.229	(0.485)	0.230	(0.468)
Buyer Fairness							0.187^{**}	(0.061)
Seller Fairness							0.015	(0.072)
Constant	10.102^{***}	(0.178)	10.071^{***}	(0.669)	10.093^{***}	(0.186)	7.928^{***}	(0.518)
N	1100		1100		1100		1100	
R^2	0.026		0.025		0.025		0.058	

Note 1: ***1%, **5%, *10% significance using standard errors clustered at the session level, and assuming coefficients have a t distribution with # of clusters (12) -1 degrees of freedom.

We now proceed to an examination of Hypothesis 3, which concerns how risk preferences of the players determine which party buys and which party sells. As our discussion highlighted, efficiency demands that the less risk averse party be the buyer. However, if the parties do not differ too much in risk attitudes, then both parties may buy with positive probability, but the less risk averse player is more likely to be the buyer. However, once risk attitudes are sufficiently different, then the Nash bargaining solution predicts that the less risk averse player buys with certainty. In Figure 4(a), we plot the frequency with which the less risk averse player is the buyer, decomposing into bins based on the difference in risk preferences. As can be seen, for $|\rho^{\text{buyer}} - \rho^{\text{seller}}| < 0.4$, only about 45% of the time does the less risk averse player buy. However, for $|\rho^{\text{buyer}} - \rho^{\text{seller}}| \in [0.4, 0.6)$, the frequency jumps to over 60%. Figure 4(b) reports linear and logistic fixed effects regressions where the dependent variable takes value 1 if the less risk averse subject was the buyer. As controls, we include the difference in risk coefficients between the more and less risk averse subject ($\rho^h - \rho^l$) as well as a variable which gives the normalized variance of the distribution. The results confirm that there is partial sorting according to risk preferences, especially when the difference between the two players is relatively large, which is consistent with Hypothesis 3. Furthermore, there is suggestive evidence that efficient sorting is more likely to happen when the underlying distribution is riskier.

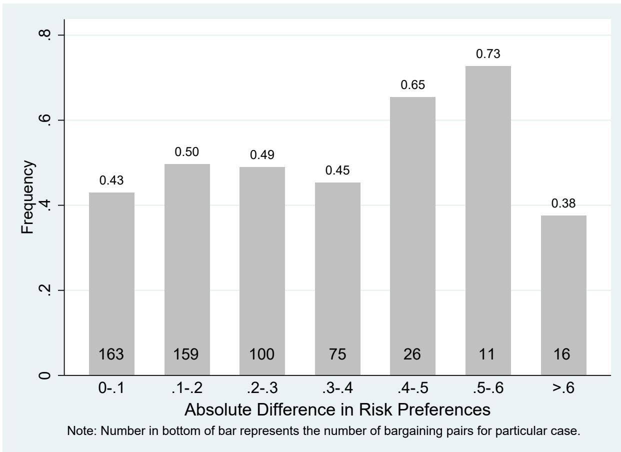
We now turn our attention to communication. We already showed above that allowing communication significantly reduces the likelihood of disagreement (Hypothesis 4(a)). However, in contrast to Hypothesis 4(b), there is no difference between efficient risk taking depending on whether or not communication is present. When subjects could chat, players efficiently sorted into buyer/seller roles 46.4% of the time, while when subjects could not chat, they actually efficiently sorted into buyer/seller roles more often: 49.2% of the time. However, the difference is not significant (Mann-Whitney rank-sum test, $p = 0.818$).

Therefore, we have that:

Result 2. *We find some support for Hypothesis 3 in that, as the difference in risk aversion between players grows, the less risk averse player is more likely to buy. Hypothesis 4(a) is supported, with agreements being significantly more frequent when communication is possible. However, in*

Figure 4: Does The Less Risk Averse Subject Buy?

(a) Frequency of Efficient Risk Taking



(b) Fixed Effects Regression (Less Risk Averse Subject Buys)

	Linear		Logit	
$\rho^h - \rho^l$	0.293**	(0.132)	1.176**	(0.480)
Variance	0.131	(0.078)	0.534***	(0.189)
Constant	0.339***	(0.039)		
N	1100		1079	
R^2/LL	0.008		-496.952	

Note 1: ***1%, **5%, *10% significance. Linear model reports standard errors clustered at the session level, and assuming coefficients have a t distribution with # of clusters (12) -1 degrees of freedom.
Note 2: ρ^h (ρ^l) denotes the risk coefficient of the more (less) risk averse player.

contrast to Hypothesis 4(b), allowing players to communicate does not improve efficient sorting into buyer/seller roles.

Lastly, with respect to our hypothesis tests, we turn our attention to the role of fairness. First, observe that consistent with the intuition in Section 2.3.1, Table 2 shows that the selling price is positively associated with the fairness preference of the buyer (although the fairness idea of the seller does not appear to influence the selling price). Additionally, and consistent with Hypothesis 5, there appears to be some sorting based on fairness preferences. A random effects regression of an indicator variable for `Fairness Idea Seller` $\leq$ `Fairness Idea Buyer` on an indicator for the Communication treatment gives a positive and significant coefficient (coeff: 0.073; $p-$value: 0.048). Moreover, the constant is 0.556, which is marginally significantly different from 0.5 ($p = 0.056$). That is, there is some evidence that players sort buyer/seller roles according to fairness ideas, and that this process is facilitated by the presence of communication.

From Table 1 it also appears that the average agreed price is closer to the average fairness idea in the communication treatment. We formally test this by considering the absolute difference between the agreed price and a player's fairness idea and then conducting a Mann-Whitney rank sum test by treatment. Absent communication, the absolute difference is 2.72, while with communication, the absolute difference is 2.00. This treatment difference is significant ($p = 0.007$). We conclude this discussion with the following:

RESULT 3. *Consistent with Hypothesis 5, fairness ideas influence bargaining outcomes. There is evidence of sorting with the buyer being more likely to have the higher fairness idea. This relationship is enhanced by communication. Furthermore, communication leads to agreed prices which are significantly closer to players' fairness ideas.*

Table 3: First and Last Offers to Buy/Sell

Offer	Agree Buyer (%)	Both Buy (%)	Both Sell (%)
First Offers	55.66	24.34	20.00
Final Offers	60.19	22.64	17.17

Note: The table contains only those bargaining pairs in which both subjects made at least one offer.

3.3 Bargaining Process

One of the predictions from our numerical analysis of the Nash bargaining solution is that players would prefer to commit to being the buyer than the seller. If this is true, then we should see that players are more likely to propose that they buy their partner's share of the business/risky asset. Indeed, if we look at first offers, then we see that 58.2% of first offers are such that the proposer should be the buyer. This is significantly different from 50% according to a Wilcoxon sign-rank test ($p = 0.011$) based on session averages. Indeed, this continues through the bargaining process with 58.8% of final offers being such that the proposer should be the buyer. Again, a Wilcoxon sign-rank test rejects the null that this percentage is equal to 50% ($p = 0.004$).

Because of the heterogeneity (and preference towards buying) we see that bargaining pairs frequently disagree over who should be the buyer. Specifically, Table 3 shows the frequency with which players either agree on the identity of the buyer, both wish to buy and both wish to sell. As can be seen, 44.34% of initial offers see disagreement over the identity of the buyer from the first offer and this only decreases to 39.81% by the last offers. When there is disagreement over the identity of the buyer, it is more frequent that both subjects wish to buy. For opening offers the difference is not significant, but for final offers it is marginally significant according to a Wilcoxon sign-rank test ($p = 0.0996$).

Previous research has shown that opening offers have a strong anchoring effect on final negotiated agreements (Galinsky and Mussweiler, 2001). In our setting, there are two dimensions to consider: whether the subject buys or not and the price. We consider each of these in Table 4. As can be seen from panel (a), a subject whose opening offer is to be the buyer ends up buying 63.74% of the time, while a subject whose opening offer is to sell ends up buying on 36.02% of the time. A Wilcoxon signed rank test easily rejects that subjects who initially propose to buy or sell end up buying with the same frequency ($p \ll 0.01$). Thus, we see clear evidence for anchoring with respect to the identity of the buyer.[19]

Panel (b) reports a series of random effects regressions to see how opening offers influence the final agreed price. The first column includes only the opening price offers by each player in a pair, as well as indicators for the underlying pie-distribution. As can be seen, opening offers are positively and significantly associated with the final price. In column (2) of Table 4(b) we include indicator variables for whether the opening offers agree on the identity of the buyer, or whether

[19] In Table A.1 in the appendix, we provide a regression based approach (similar to Table 4(b) for the agreed price) to show the anchoring effect of first offers on the identity of the buyer. In all specifications, the coefficient on an indicator which takes value 1 if the player's first offer was that they should be the buyer is always positive and highly significant.

Table 4: The Effect of Opening Offers on Final Agreements

(a) Who Buys

Opening Offer	Frequency Subject Buys in Agreement (%)
Buy	63.74
Sell	36.02

(b) Anchoring on Price (Fixed-Effects Regression; Dep. Var: Agreed Price)

	(1)	(2)	(3)	(4)
Own Price Offer	0.114^{***} (0.031)	0.204^{***} (0.029)	0.203^{***} (0.029)	0.194^{***} (0.027)
Other Price Offer	0.122^{***} (0.029)	0.213^{***} (0.028)	0.211^{***} (0.027)	0.201^{***} (0.026)
$\mathbf{1}[(14,26)]$	−0.142 (0.262)	0.026 (0.262)	0.027 (0.261)	0.172 (0.248)
$\mathbf{1}[(12,28)]$	-0.525^{*} (0.310)	−0.257 (0.298)	−0.262 (0.296)	0.078 (0.300)
Agree Buyer		1.264^{***} (0.260)	1.258^{***} (0.248)	1.278^{***} (0.257)
Both Buy		2.420^{***} (0.240)	2.380^{***} (0.254)	2.339^{***} (0.257)
Own ρ			0.622 (0.711)	0.561 (0.651)
Other ρ			0.571 (0.715)	0.511 (0.651)
Own Fairness			0.105^{***} (0.033)	0.105^{***} (0.033)
Other Fairness				0.103^{***} (0.032)
Constant	7.123^{***} (0.721)	3.958^{***} (0.768)	3.466^{***} (1.062)	1.642 (1.188)
Observations	1008	1008	1008	1008
R^2	0.096	0.162	0.167	0.183

Note: ***1%, **5%, *10% significance using standard errors clustered at the session level.

both players want to buy (hence the base category is when both players want to sell). As can be seen, relative to the baseline, the price is significantly higher when the players agree on who will buy and higher still when both players want to buy. This is intuitive because by revealing a willingness to buy indicates that the player(s) has(have) a higher risk tolerance than those who reveal that they prefer to sell. Column (3) confirms a result reported in Table 2 that elicited risk preferences do not appear to influence the agreed upon price. Lastly, Columns (3) and (4) show that fairness ideals are significantly, positively associated with the final price. That is, the higher is the perceived fair price, the higher is the eventually agreed upon price.

We can summarize our results on the bargaining process as follows:

Result 4. *There is frequent conflict over the identity of the buyer, with players preferring to be the buyer a majority of the time. First offers are highly determinative of final outcomes, both in terms of the identity of the buyer as well as the final price. Fairness ideas are also predictive of the final price.*

4 The Role of Communication

Hypothesis 4 posited that communication might increase the likelihood of efficient sorting by risk preferences; that is, that the less risk averse player is the buyer. As noted above, we do not find evidence to support this hypothesis. However, we also showed that, consistent with the literature, the ability to communicate did increase the frequency of the parties successfully reaching an agreement. It also increased the frequency of sorting into buyer/seller roles based on fairness ideas.

To dig deeper into the chat messages, we searched the text communication for key words related to risk and fairness and coded variables for risk and fairness if any of those words were contained in the chat for the group.[20] Fairness was mentioned in approximately 21% of bargaining pairs, while risk was mentioned in approximately 18% of bargaining rounds, and there was no apparent pattern based on the underlying risk of the pie distribution. In Table 5 we report the frequency of agreements and the average agreed price for four combinations of whether or not the chat mentioned risk and/or fairness.

Table 5: The Impact of Chat Messages on Outcome Variables

(a) Agreements (%)

		Risk	
		No	Yes
Fairness	No	97.98	98.33
	Yes	96.06	94.44

(b) Agreed Price

		Risk	
		No	Yes
Fairness	No	9.64	8.88
	Yes	8.19	8.93

As can be seen, in panel (a), there is very little difference in the frequency of agreements depending on the chat content and no pairwise test is statistically significant. When it comes to the agreed price, there are some differences. Specifically, when the chat does not mention either risk or fairness, the agreed price is 9.64. In every other case, where one or both of risk or fairness are mentioned, the agreed price is lower. Specifically, (i) risk only: price of 8.88 ($p = 0.094$); (ii) fairness only: price of 8.19 ($p = 0.063$); or (iii) both risk and fairness: price of 8.93 ($p = 0.063$). Interestingly, when the chat talks about both risk and fairness, the agreed price is closest to the case when only risk is mentioned, suggesting that risk may be the more salient feature, even if mentioning fairness alone is potentially more effective in securing a lower price.

We summarize our results as:

RESULT 5. *Subjects discuss risk and fairness approximately 20% of the time. Such discussions do not impact the likelihood of disagreement, but mentions of either risk or fairness are associated with (weakly) significantly lower prices.*

5 Conclusion

In this paper we experimentally studied the problem of partnership dissolution. Unlike much of the literature, rather than focusing on private information of underlying valuations, we studied the issue of the underlying risk of the underlying business. Because of this, dissolving the partnership naturally leads to an asymmetric exposure to risk. The buyer of the partnership is now full owner of a risky asset, while the seller receives a guaranteed cash payment.

Our results show that buyers are generally compensated for risk (the average price was almost always less than half the expected value) and the amount of compensation for risk increased as

[20]The words coded under the risk category were: risk, risky, risking, risks, chance, chances, gamble, gambler, safe, safer, safest, "luck never favors", odds and the incorrectly spelled word "rish". The words coded under the fairness category were: equal, equally, fair, unfair, balanced, mutual and reasonable.

the underlying risk increased. Consistent with theory, there was some sorting according to risk preferences, with the less risk averse player being somewhat more likely to buy and the more risk averse player being somewhat more likely to sell. However, the differences were much less than would be expected by theory. Indeed, our results showed that a majority of subjects, through their offers, revealed a preference to be the buyer (and therefore expose themselves to risk). However, beside these results, risk preferences did not appear to have much of a role in influencing the outcome.

The effect of communication was somewhat mixed. While the ability to communicate did significantly increase the frequency of agreement, it did not facilitate sorting of buyer/seller roles according to risk preferences. It did, however, facilitate sorting based on fairness ideas. Moreover, we also saw that the content of messages is important. When the chat log of a negotiation mentioned either risk or fairness concerns, the agreed price was significantly lower than when neither of these issues were discussed. Therefore, communication does have an important role to play in negotiations, it just needs to be focused on relevant factors like risk and fairness.

One other interesting feature of our experiment is that, despite having to negotiate two items – a price and risk exposure – there was surprisingly little disagreement – even less than Embrey et al. (2021), where risk exposure was exogenously given and players only had to negotiate a price. It seems like this extra dimension actually facilitated agreements. However, upon further thought, this is somewhat intuitive in that it imposes bounds on the type of offers players can credibly make. For example, when a player would make a low-ball offer to buy, it was not uncommon to see something to the effect of "I won't sell at that price, but I'm happy to buy from you at it" as a reply, thereby pointing out the unreasonableness of the offer, and encouraging concessions to a more reasonable price.

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A Theoretical Basis For Hypotheses and Additional Experimental Results

A.1 Randomization Over The Identity of the Buyer

Let us restrict attention to CRRA utility functions of the form $u(x) = \frac{1}{1-\rho}x^{1-\rho}$, where we further restrict attention to $\rho \in (0, 1)$.

LEMMA 1. *If players are symmetric, have preferences such that $u(x) = \frac{1}{1-\rho}x^{1-\rho}$, where $\rho \in (0, 1)$ and one player commits to being the buyer, then the buyer receives a higher utility than the seller.*

Proof. Given that one player commits to being the buyer, the objective function for the Nash bargaining solution is:

$$\left[\frac{1}{2}u(\pi - \mu - p) + \frac{1}{2}u(\pi + \mu - p)\right] u(p)$$

and the first-order condition can be rewritten as:

$$\frac{0.5u(\pi - \mu - p) + 0.5u(\pi + \mu - p)}{u(p)} = \frac{0.5u'(\pi - \mu - p) + 0.5u'(\pi + \mu - p)}{u'(p)}.$$

Under the assumptions on our utility function, it can be verified that the left-hand side of this equation is decreasing in p, while the right-hand side of this equation is increasing in p. We show that this equation can only be satisfied when both sides are equal and greater than 1.

Consider the value, p, such that the left-hand side of the above equation is equal to 1. It is not possible to solve this analytically for all $\rho \in (0, 1)$. However, under the assumption of log utility (i.e., the limit as $\rho \to 1$), we can solve for this critical value of p. A little algebra leads to $p^* = \frac{\pi^2 - \mu^2}{2\pi}$. Therefore, for any $\rho \in (0, 1)$, the critical value must be $p' > p^*$.

To complete the proof, we show that the right-hand side of the FOC, above, must be at least 1 at p^* for any $\rho \in (0, 1)$. Combined with the fact that the right-hand side is increasing in p completes the proof.

Substituting in for p^* and for our specific utility function gives us:

$$\frac{1}{2}[(\pi - \mu)(\pi + \mu)]^{\rho} \left[(\pi - \mu)^{-2\rho} + (\pi + \mu)^{-2\rho}\right]$$

and we need to show that this is greater than or equal to 1. Further simplification gives us:

$$\left(\frac{\pi + \mu}{\pi - \mu}\right)^{\rho} + \left(\frac{\pi - \mu}{\pi + \mu}\right)^{\rho} \geq 2.$$

Let $\alpha := {}^{\pi+\mu}/_{\pi-\mu} > 1$ and rewrite the above inequality as:

$$\alpha^{\rho} + \left(\frac{1}{\alpha}\right)^{\rho} \geq 2,$$

which can be further simplified to:

$$\beta^2 - 2\beta + 1 \geq 0$$

where $\beta := \alpha^\rho$. Finally, it is easily seen that the left-hand side of this inequality can be expressed as $(\beta - 1)^2$ and this is, indeed, greater than or equal to 0.

Thus, we have proven that when the two players are symmetric and one player commits to being the buyer, then the buyer is better off in expected utility terms than the seller. □

We now show the following:

Lemma 2. *When players have identical CRRA utility functions with $\rho \in (0, 1)$, then the NBR must randomize over the identity of the buyer.*

Proof. Let $u_s(p) = \frac{1}{1-\rho} p^{1-\rho}$ be the utility of the seller. Let $u_b(p) = \frac{1}{2(1-\rho)}\left((\pi + \mu - p)^{1-\rho} + (\pi - \mu - p)^{1-\rho}\right)$ be the utility of the buyer. Also, let $\lambda \in [0, 1]$ denote the probability of the first player being the buyer. Then, the objective function for the Nash product is:

$$NP(p, \lambda) = (\lambda u_b(p) + (1 - \lambda)u_s(p)) \times ((1 - \lambda)u_b(p) + \lambda u_s(p)).$$

Observe that the Nash product at $\lambda = 0$ and at $\lambda = 1$ is simply, $NB(p, 0) = NB(p, 1) = u_b(p)u_s(p)$. On the other hand, we have:

$$NB(p, 0.5) = \left(\frac{1}{4}\right) u_b(p)^2 + \left(\frac{1}{2}\right) u_b(p)u_s(p) + \left(\frac{1}{4}\right) u_s(p)^2.$$

Furthermore, one can show that

$$NB(p, 0.5) - NB(p, 1) = \frac{1}{4} (u_b(p) - u_s(p))^2 \geq 0,$$

with strict inequality whenever $u_b(p) \neq u_s(p)$. Given our previous result that $u_b(p) > u_s(p)$ whenever one player commits to being the buyer, this shows that the Nash bargaining solution must have $\lambda \in (0, 1)$. Indeed, by taking first-order conditions, one can see that the optimal solution must be at $\lambda = 1/2$.

Thus, when players are symmetric, the NBS gives each player an equal chance to be the buyer or the seller. □

As a last step, we show that when players are symmetric, there is no Pareto improving reallocation possible from the Nash bargaining solution which uniformly randomizes over the identity of the buyer such that one player is the buyer for sure and the other player is the seller for sure. That is,

Lemma 3. *Suppose players are symmetric with CRRA utility and $\rho \in (0, 1)$. Let $H(p) = 0.5(u_b(p) + u_s(p))$ for $p \in [0, \pi - \mu]$. Then, $H(p)$ is strictly concave in p and has a unique global optimizer, denoted by p^*. Furthermore, there does not exist p' such that $u_b(p') \geq H(p^*)$ and $u_s(p') \geq H(p^*)$.*[21]

[21] Observe that p^* is the price that maximizes the Nash product when uniformly randomizing over the identity of the buyer.

Proof. First, observe that $u_b(p)$ is decreasing and strictly concave in p and further that $\lim_{p\to\pi-\mu} u_b'(p) = -\infty$, while $\lim_{p\to 0} u_b'(p)$ is negative but finite. Second, observe that $u_s(p)$ is increasing and strictly concave in p and further that $\lim_{p\to 0} u_s'(p) = \infty$, while $\lim_{p\to\pi-\mu} u_s'(p)$ is positive but finite. This shows that $H(p)$ is strictly concave with a unique global maximizer $p^* \in (0, \pi - \mu)$.

Next, suppose to the contrary that there exists $y \in (0, \pi - \mu)$ such that $u_b(y) \geq H(p^*)$ and $u_s(y) \geq H(p^*)$. Adding these two inequalities and dividing by 2 yields:

$$H(y) = 0.5(u_b(y) + u_s(y)) \geq H(p^*).$$

However, this contradicts that p^* is the unique global maximizer of $H(p)$. □

REMARK 1. *Notice that the proof of Lemma 3 does not depend on the CRRA assumption. The result holds so long as we can show that $H(p)$ has a unique global maximizer in the interior. This will be true so long as $u_b'(0) + u_s'(0) > 0$ and $u_b'(\pi - \mu) + u_s'(\pi - \mu) < 0$, which would seem likely to hold for a range of underlying strictly concave utility functions.*

With these three results in hand, and because of the underlying continuity of the problem, we are now able to conclude that if players are not symmetric (without loss of generality, $0 < \rho_1 < \rho_2 < 1$) but not too different in terms of risk preference (i.e., $|\rho_1 - \rho_2|$ is sufficiently small), then

1. The Nash bargaining solution randomizes (though not uniformly) over the identity of the buyer; and

2. There does not exist a price p' at which the less risk averse partner buys with probability 1 which is a Pareto improvement over the Nash bargaining solution.

That is, at least for some parameter range, the Nash bargaining solution places strictly positive probability on the *more* risk averse partner buying the partnership. While this may seem counter-intuitive, remember that both players are risk averse. Therefore, randomizing over the identity of the buyer is a way to share diversify the risk, even if it means that the more risk averse partner is sometimes buying. To be sure, we do not mean to claim that the range is particularly large. Indeed, when the differences in risk preferences grow, eventually it is optimal for the less risk averse partner to buy for sure. Our numerical analysis, below, shows that for the vast majority of the parameter space $(\rho_1, \rho_2) \in (0, 1)^2$, the Nash bargaining solution specifies that the *less* risk averse partner buys the partnership with probability 1.

A.2 Hypotheses 1 and 2

In this section we provide some analytical results to support our hypotheses. We focus on the case of CRRA utility with $\rho_i \in (0, 1)$, and for the case of Hypotheses 1 and 2 we restrict attention to the case in which one player (WLOG, player 1) commits to being the buyer. This is both for analytical tractability and because our numerical calculations suggest the region of risk parameters, (ρ_1, ρ_2) such that both players buy with positive probability is fairly small.

When player 1 commits to being the buyer, then the objective function to compute the NBS is given by:

$$\left(\frac{1}{2}\frac{1}{1-\rho_1}(\pi-\mu-p)^{1-\rho_1}+\frac{1}{2}\frac{1}{1-\rho_1}(\pi+\mu-p)^{1-\rho_1}\right)\left(\frac{1}{1-\rho_2}p^{1-\rho_2}\right).$$

The first-order condition is:

$$\begin{aligned} 0 &= \left(\frac{1}{2}\frac{1}{1-\rho_1}(\pi-\mu-p)^{1-\rho_1}+\frac{1}{2}\frac{1}{1-\rho_1}(\pi+\mu-p)^{1-\rho_1}\right)p^{-\rho_2} \\ &- \frac{1}{2}\left((\pi-\mu-p)^{-\rho_1}+(\pi+\mu-p)^{-\rho_1}\right)\left(\frac{1}{1-\rho_2}p^{1-\rho_2}\right). \end{aligned}$$

It is not possible to provide an analytical solution to this problem, but we can use the Implicit Function Theorem to compute important comparative statics such as $\partial p/\partial \mu$ (Hypothesis 1) as well as $\partial p/\partial \rho_1$ and $\partial p/\partial \rho_2$ (Hypothesis 2). As we are just interested in the sign of these partial derivatives, we will limit our analysis to achieving this goal.

First, observe that the second derivative of the objective function is easily seen to be negative. Specifically, the second derivative is:

$$\begin{aligned} &\frac{1}{2}p^{-\rho_2}\left(\frac{p\rho_1\left(-(\pi-\mu-p)^{-\rho_1-1}-(\pi+\mu-p)^{-\rho_1-1}\right)}{1-\rho_2}-\frac{\rho_2\left((\pi-\mu-p)^{1-\rho_1}+(\pi+\mu-p)^{1-\rho_1}\right)}{p-p\rho_1}\right. \\ &\quad \left. -2(\pi-\mu-p)^{-\rho_1}-2(\pi+\mu-p)^{-\rho_1}\right)<0. \end{aligned} \tag{1}$$

Therefore, the sign of the partial derivative of p with respect to variable x will be given by the sign of the partial derivative of the FOC with respect to that variable, x.

The partial derivatives with respect to the variables of interest are proportional to:[22]

$$\begin{aligned} \mu &: \frac{p\rho_1\left((\pi+\mu-p)^{-\rho_1-1}-(\pi-\mu-p)^{-\rho_1-1}\right)}{1-\rho_2}-(\pi-\mu-p)^{-\rho_1}+(\pi+\mu-p)^{-\rho_1} \\ \rho_1 &: \frac{p\left((\pi-\mu-p)^{-\rho_1}\log(\pi-\mu-p)+(\pi+\mu-p)^{-\rho_1}\log(\pi+\mu-p)\right)}{1-\rho_2}+\frac{(\pi-\mu-p)^{1-\rho_1}}{(1-\rho_1)^2} \\ &\quad +\frac{(\pi+\mu-p)^{1-\rho_1}}{(1-\rho_1)^2}-\frac{(\pi-\mu-p)^{1-\rho_1}\log(\pi-\mu-p)}{1-\rho_1}-\frac{(\pi+\mu-p)^{1-\rho_1}\log(\pi+\mu-p)}{1-\rho_1} \\ \rho_2 &: \frac{p\left(-(\pi-\mu-p)^{-\rho_1}-(\pi+\mu-p)^{-\rho_1}\right)}{(1-\rho_2)^2}+\frac{p\log(p)\left((\pi-\mu-p)^{-\rho_1}+(\pi+\mu-p)^{-\rho_1}\right)}{1-\rho_2} \\ &\quad -\frac{\log(p)\left((\pi-\mu-p)^{1-\rho_1}+(\pi+\mu-p)^{1-\rho_1}\right)}{1-\rho_1} \end{aligned}$$

Considering the first equation, since $\rho_1 \in (0,1)$, and $(\pi+\mu-p) > (\pi-\mu-p)$, we see that this equation must be negative. That is, as indicated by Hypothesis 1, the price is decreasing in risk.

[22] In all cases, we omit a term $Cp^{-\rho_2}$, where C is a positive constant.

Consider now the second equation, which looks at the effect of the risk preferences of the buyer, ρ_1. We know that the first term is positive. We can rewrite the last four terms as:

$$\log(\pi-\mu-p)\left(\frac{p}{1-\rho_2}(\pi-\mu-p)^{-\rho_1}-\frac{(\pi-\mu-p)^{1-\rho_1}}{1-\rho_1}\right)$$
$$+\log(\pi+\mu-p)\left(\frac{p}{1-\rho_2}(\pi+\mu-p)^{-\rho_1}-\frac{(\pi+\mu-p)^{1-\rho_1}}{1-\rho_1}\right).$$

Now, noting that the first-order condition, (1), must be satisfied, we can conclude that this expression must be positive. Therefore, we have proven that $\partial p/\partial \rho_1 > 0$. That is, as the buyer becomes more risk averse, the price at which the buyer buys increases.

Finally, consider the last equation. Using the fact that the first-order condition (1) must be satisfied, we actually see that the second and third terms cancel, leaving only the first term, which is negative. Therefore, we have proven that $\partial p/\partial \rho_2 < 0$. That is, as the seller becomes more risk averse, the selling price decreases. These last two results, therefore, provide the theoretical foundation for Hypothesis 2.

A.3 Hypothesis 3

It is difficult to analytically provide a comparative static analysis of how the probability of buying varies with risk preferences. Instead we provide the results of a numerical exercise in Figure A.1 for CRRA utility.[23] As can be seen, for the vast majority of the space, the buyer is deterministic. It is only in the a small region around equal risk preferences that the Nash bargaining solution randomizes over the identity of the buyer. When risk preferences are modestly far apart, the efficiency gain from having the less risk averse player buy outweighs any benefit of using randomization as a way to “share” the risk between the two players.

A.4 Additional Experimental Results

In Table A.1, we provide additional analysis on the impact of anchoring with respect to the identity of the buyer by successively adding control variables. As can be seen, regardless of the control variables included, the coefficient on **1**[Offer to Buy] is always positive and highly significant.

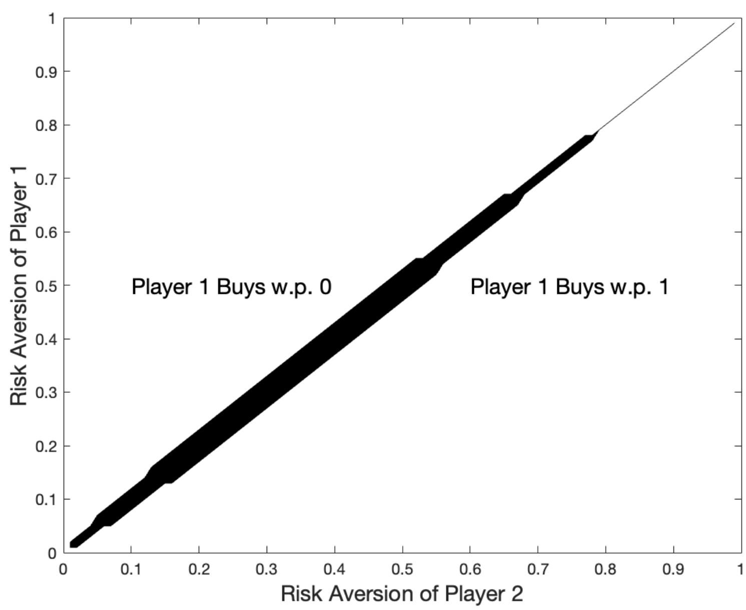
[23] Increasing numbers indicate greater risk aversion.

Table A.1: The Effect of Opening Offers on Final Agreements About Buyer Identity

1[Offer to Buy]	0.276***	(0.037)	0.276***	(0.038)	0.277***	(0.038)	0.277***	(0.038)	0.324***	(0.094)	0.319***	(0.098)
Own ρ			−0.019	(0.122)	−0.020	(0.122)	−0.020	(0.122)	−0.022	(0.116)	−0.022	(0.116)
Other ρ			−0.016	(0.135)	−0.014	(0.135)	−0.014	(0.135)	−0.022	(0.131)	−0.022	(0.130)
Own Fairness					0.003	(0.005)	0.003	(0.005)	0.001	(0.005)	0.001	(0.005)
Other Fairness					−0.003	(0.007)	−0.003	(0.007)	−0.004	(0.006)	−0.004	(0.006)
1[$(14, 26)$]							0.010	(0.012)	0.019	(0.015)	0.019	(0.015)
1[$(12, 28)$]							0.002	(0.009)	0.022*	(0.012)	0.022*	(0.012)
1[Offer to Buy]× Price									0.003	(0.010)	0.003	(0.010)
Price									0.015**	(0.006)	0.014**	(0.006)
Communication											−0.009	(0.015)
Constant	0.361***	(0.020)	0.376***	(0.021)	0.379***	(0.044)	0.372***	(0.046)	0.215***	(0.068)	0.222***	(0.075)
Observations	1054		1054		1054		1054		1054		1054	
R^2	0.077		0.077		0.077		0.077		0.087		0.087	

Note: ***1%, **5%, *10% significance using standard errors clustered at the session level.

Figure A.1: Probability That Player 1 Buys Given Risk Preferences



Note: The black shaded area denote the region of the parameter space in which the NBS randomizes over the identity of the buyer. In the upper-left region, where player 1 is sufficiently more risk averse than player 2, then the NBS specifies that player 1 never buys. Similarly, in the lower-right region where player 1 is sufficiently less risk averse than player 2, the NBS specifies that player 1 always buys.

B Instructions For No-Communication Treatment

Welcome

You are about to participate in a session on interactive decision-making. Thank you for agreeing to take part. The session should last about 90 minutes.

You should have already turned off all mobile phones, smart phones, tablets and all other such devices by now. If not, please do so immediately. These devices must remain switched off throughout the session. Place them in your bag or on the floor besides you

The entire session, including all interaction between you and other participants, will take place on an assigned computer. You are not allowed to talk or otherwise communicate with the other participants in any other way during the session. You are asked to follow these rules throughout the session. Should you fail to do so, we will have to exclude you from this (and future) session(s).

We will start with a brief instruction period. Please read these instructions carefully. They are identical for all participants in this session with whom you will interact. If you have any questions about these instructions now, or at any other time during the experiment, then please raise your hand.

Structure of the session

This session has two parts. Instructions for part 1 are detailed below. Part 2 consists of a survey and individual choice questions. Instructions for part 2 will be given once part 1 has been completed. Parts 1 and 2 are independent.

Compensation for participation in this session

You will be able to earn money for your decisions in both parts of this session. What you will earn from part 1 will depend on your decisions, the decisions of others and chance. Further details are given below. What you will earn from part 2 will only depend on your decisions and chance. Further details will be given after part 1 has been completed. In the instructions, and in all decision tasks that follow, payoffs are reported in Dollars (USD). Your final payment will be the sum of your earnings from the two parts. Final payment takes place in cash at the end of the session. Your decisions and earnings in the session will remain anonymous.

Instructions for Part I

Part 1 is structured as follows:

1. Part 1 consists of 9 periods.

2. At the beginning of a period, you will be randomly paired with another participant.

3. During the period, you will interact only with the participant you have been paired with for that period. We refer to this participant as your match.

Description of a period

4. You and your match are equal owners of a partnership; however, because of a dispute, the partnership must now be dissolved.

5. During the period you and your match will negotiate the dissolution of the partnership. That is, you will negotiate a purchase price, as well as which party buys the other's share and which party sells their share of the partnership.

6. The value from owning the partnership is not known with certainty. In particular, the partnership will take one of two possible values, with each amount being equally likely to be the actual value.

7. At the beginning of the period, you and your match will be given a list of possible values from owning the partnership. Neither you nor your match will know the actual value from owning the partnership until the end of the period. Only at this point will the true value be determined by randomly selecting from the list of possible amounts.

8. Negotiations will take place through the computer interface. You will have 4 minutes in which to negotiate. The time limit is binding: if you and your match do not reach an agreement during this time limit you will both receive zero for the period.

9. During the negotiation time, you may make offers at any time. An offer specifies a purchase price and whether you wish to buy your match's share of the partnership or sell your share of the partnership. The only restrictions on the offers you can make are: 1) the offer must be larger than zero, and 2) the offer must be less than the smallest possible value for the partnership. The computer interface will ensure these restrictions are met. Finally, only the current offer, that is the most recent offer made by a participant, can be accepted by the other participant.

10. An agreement is reached when either you or your match accept the other's current offer. Once an offer has been accepted, negotiations for the period end.

11. If you and your match reach an agreement, then the party who sells their share will receive the agreed upon purchase price, while the party who buys the other's share of the partnership will receive the realized value from owning the partnership less the purchase price. That is, the party who sells will receive a fixed payment, while the payoff of the party who buys is uncertain, since it depends on the realized value from owning the partnership.

12. A period is ended either by an agreement or by the elapse of the negotiating time limit. At the end of a period.

13. At the end of a period the purchase price (in the event of an agreement), value from owning the partnership, as well as your payoff for the period and that of your match will all be determined and displayed.

The end of part 1

14. After a period is finished, you will be randomly paired for a new period. Note that, each period, you are matched in such a way that you will never interact with the same participant more than once. Part 1 consists of 9 such periods.

15. At the end of part 1 – that is, after the ninth period – one period will be selected at random. The payoff you gained during the selected period will be used to as your final payoff for part 1.

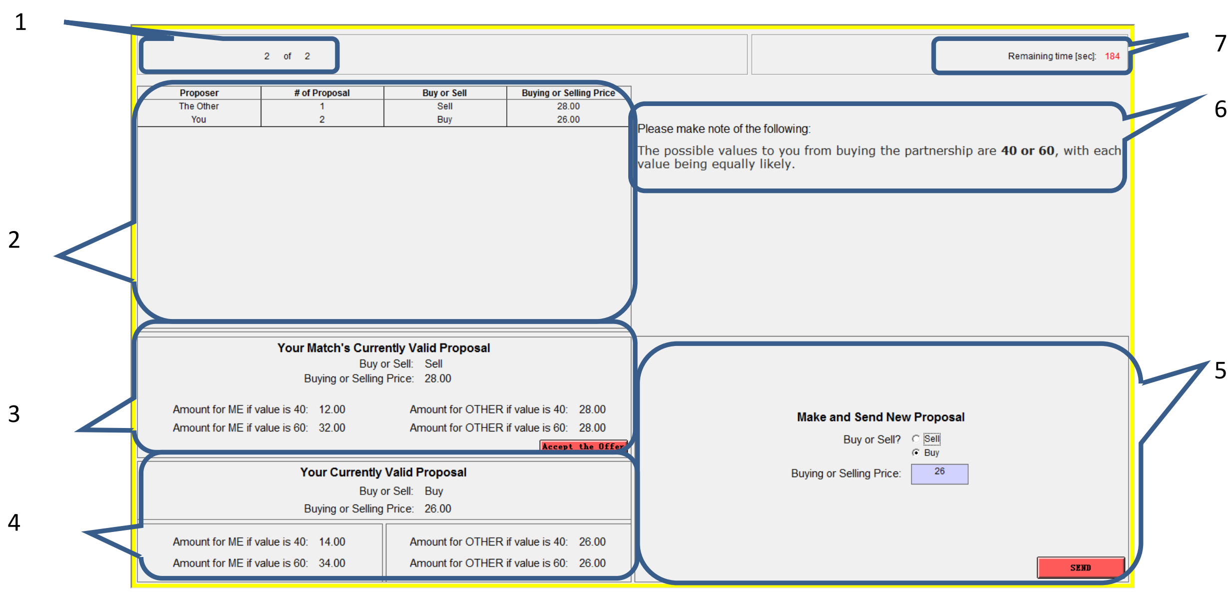
16. After your final payoff for part 1 has been calculated, the session will move on to part 2. Instructions for part 2 will be displayed on your computer terminal. Please read them carefully and proceed through part 2 at your own pace.

Making and Accepting Offers

An example

The following screenshot is used as an example to illustrate how to use the computer interface to make and accept offers. The screen for both parties is identical.

Please note that the possible sizes of the pie and the offers shown on the screen are not values that you will see during the session itself. They have been selected for illustrative purposes only.



Key

1. Period number box: The number of the current period.

2. Proposal history box: This shows the history of offers you and your match have made.

3. Your match's current offer box: Details of the current offer made by your match. To accept their offer, click on the "Accept the Offer" button.
4. Your current offer box: Details of your current offer.
5. New offer box: To make a new offer enter a value for the fixed payment and click the "SEND" button.
6. Reminder box: A reminder of the possible values from owning the partnership. Each amount is equally likely.
7. Timer box: The amount of time remaining

C Risk Elicitation Screenshot

Figure C.1: Example Screenshot From Risk Elicitation