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The effect of link costs on simple buyer–seller networks [☆]

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ABSTRACT

We examine experimentally how link costs affect the formation of links between a single seller and two potential buyers as well as the ensuing bargaining. Theory predicts that link costs lead to less competitive networks, with one link rather than two links, and that link costs do not affect the bargaining outcomes conditional on the network. We find support for the first but not the second prediction. 2-link networks form less frequently when there are link costs. Given that a 2-link network forms, however, a seller on average offers a smaller share of the pie to the buyers in the presence than in the absence of link costs. This impact of link costs can be explained by a disutility for (advantageous) inequality on the part of the seller.

1. Introduction

Buyers and sellers often have to establish a 'link' between them before they can engage in exchange. The collection of links between buyers and sellers (i.e., the 'network') exerts a strong influence on the outcomes of exchange. Who can interact with whom not only affects the gains from exchange but also how these gains are distributed. Typically, agents with more links and trading opportunities are in a better bargaining position than more isolated agents. For example, Corominas-Bosch (2004) showed that a decomposition of buyer–seller networks allows 'even' and competitive sub-networks to be identified; surplus is shared evenly in the even sub-networks, whereas the short side of the market extracts all surplus in the competitive sub-networks. This implies that, similar to market entry, there is a strong strategic element in the formation of links and that the costs of forming a link play a key role.

The present paper uses experiments to analyze behavior in a simple game with endogenous network formation in addition to endogenous interaction within the network. We address two basic questions. First, we ask how network *formation* is affected by the presence of link costs. In particular, we examine whether competitive networks in which the short side of the market is predicted to get the entire surplus are less likely to arise when links are costly.

Our second question is whether the *bargaining* in the network, and not just the *formation* of the network, is affected by the costs of link formation. Because the network formation stage precedes the bargaining in the network, any link costs

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are sunk at the moment the bargaining in the network commences. Therefore, standard theory would suggest that, given the network that forms, there is no effect of link costs on the bargaining within the network. It is important to establish the absence of such an effect, as this is a basic assumption in the theoretical literature on network formation. In fact, the assumption is so standard that most papers do not mention it explicitly.

To address the two basic questions we focus on the simplest possible, non-trivial buyer–seller network formation game.[1] We analyze a two-stage game between one seller with one indivisible good and two potential buyers. In the first stage, the seller decides whether or not to form a link with each of the two buyers and the buyers simultaneously decide whether to form a link with the seller. In the second stage, conditional on the network that has been formed in the first stage, the players engage in alternating offers bargaining over a shrinking pie.

The subgame perfect equilibrium prediction of the bargaining stage of the one-shot game is such that all the surplus goes to the seller if a competitive network with two linked buyers is formed, whereas the surplus is shared if the seller is linked to one buyer only. Given the payoff predictions from the bargaining stage, in the first stage it is a weakly dominant strategy for the seller to offer a link to both buyers, if the link costs are not too high. For the buyers it is a weakly dominant strategy to offer a link to the seller if links are costless but not if links are costly. After all, the buyers are fully exploited if the competitive network is formed, so they are better off to unilaterally delete a link in case links are costly. This implies that the competitive network is the unique perfect equilibrium outcome if the links are costless, whereas the competitive network is not an equilibrium if links are costly. Hence, the first basic prediction is that the presence of link costs reduces the occurrence of competitive networks. The second basic prediction is that the presence of link costs does not affect the outcomes of bargaining given the network that forms. Once the network has been formed and bargaining starts, the link costs are sunk and the players treat them as such. To test these predictions we will employ a so-called strangers design, which allows for learning while preserving the one-shot character of the interaction to some extent.

The experimental results indicate that, as predicted, the competitive network is less prevalent in case establishing a link is costly. Contrary to the prediction though, this is due to the seller's and not the buyers' linking behavior. Remarkably, it is the seller who is more reluctant to establish a competitive network in the presence of link costs, not the buyers. Regarding the second question, we find that the presence of link costs does have an effect on the bargaining outcomes given the network that forms. Interestingly, this effect is observed when the seller is linked to two buyers but not when the seller is linked to one buyer.

We show that the effects of link costs can – at least qualitatively – be explained by assuming that player care for equality (Fehr and Schmidt, 1999). Specifically, if the seller is very averse to inequality, even if it is to her own advantage, then she will aim for an equitable outcome. This means that in a 2-link network she will compensate herself for the extra link costs she incurs relative to the buyers, while there is no need to do so in the 1-link network.

2. Related literature

Our paper is related to three different strands of experimental literature. The first strand examined the effect of competition on bargaining outcomes. Roth et al. (1991) examined bargaining between one proposer and one responder as well as bargaining between nine competing proposers and one responder. They found that competition had a dramatic effect on the bargaining outcomes. While bilateral bargaining led to a near equal division of the surplus in as much as 70 percent of the cases, with the introduction of proposer competition the occurrence of the near equal division dropped to less than five percent of the cases and almost all surplus went to the responder.[2] Closer to our paper is Charness et al. (2007) who tested the implications of the model in Corominas-Bosch's (2004), which identifies buyer–seller networks that are 'even' and those that are 'competitive', where the latter leave almost no surplus to the long side of the market. The experimental results indicated that the competitiveness of the network had a strong effect on bargaining outcomes, even though the effect was less extreme than predicted.

Analyzing the effect of competition on bargaining outcomes is also central to our study. In our experiment, however, the competitiveness of the network is not given exogenously, but comes about endogenously. In view of the finding that competitive markets and competitive networks tend to leave the long side of the market with little surplus, it is important to analyze whether such competitive networks are formed in the first place, especially if the links are costly and agents may not be able to recover their link costs.[3]

The second strand of related experimental literature focuses on network formation and examines whether behavior in a link formation game is in line with the predictions of various equilibrium concepts.[4] Falk and Kosfeld (2003), for

[1] Like Corominas-Bosch (2004) we use the labels 'buyer' and 'seller' for the players in our network game. What the players do, however, is bargaining over the division of surplus. Apart from the fact that two buyers cannot link and bargain with each other, there is nothing in the game that is specific to trading.

[2] Other experimental studies that examined the effect of competition on bargaining outcomes include Grosskopf (2003), Güth et al. (1997), and Fischbacher et al. (2003).

[3] This question is not just of theoretical interest. During the revision of the new European directive on procurement rules (EU Directive 2004/18/EC), much discussion was addressed at potential hold-up problems and bidder exploitation. The association of construction companies, for example, feared that competing bidders could be exploited to such a degree that they would not be able to earn back the costs of crafting a decent bid.

[4] See, e.g., Berninghaus et al. (2006, 2007), Callander and Plott (2005), Deck and Johnson (2004), Falk and Kosfeld (2003), Goeree et al. (2009). Also related are papers on market entry, such as Camerer and Lovallo (1999).

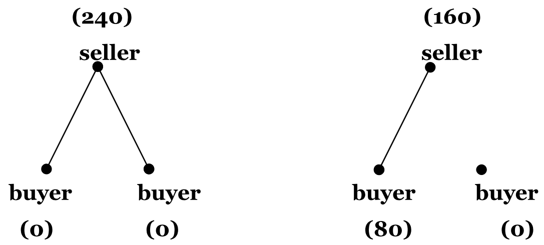


Fig. 1. The SPE payoffs in the 2-link and 1-link networks.

example, tested the model of Bala and Goyal (2000) in the lab to examine whether the formation of networks was in line with the predictions of strict Nash equilibrium. Most experimental papers on network formation focused on network formation but did not have endogenous interaction within the network. There are some notable exceptions though. Some studies implemented a two-stage network game in which players first decided with whom to form links and then played a coordination game (Berninghaus et al., 2010; Corbae and Duffy, 2008; Corten and Buskens, 2008). In Riedl and Ule (2002) the network formation stage was followed by a prisoners' dilemma. Also Brandts et al. (2009) employed treatments which had elements of both network formation and interaction over the network. In our experiment, after the linking stage, players entered into a bargaining process. Besides varying the link costs, endogenizing the bargaining process, and not just the link formation, is crucial if one aims to study the effect of link costs on the ensuing interaction within the network.

Finally, there exists an experimental literature examining the effect of sunk costs. Some studies found little evidence that sunk costs have a systematic effect on behavior (e.g., Phillips et al., 1991; Friedman et al., 2007). Others found a significant effect of the presence and the size of sunk costs. In particular, some studies suggested that sunk entry costs may induce players to coordinate on a better equilibrium in case there are multiple (Pareto-ranked) equilibria (Cachon and Camerer, 1996; Offerman and Potters, 2006). Others found an effect of sunk investment costs that seemed to be better explained by a concern for fairness (Ellingsen and Johannesson, 2005). No study, however, has yet examined the effect of linking or entry costs on bargaining behavior.[5] Nevertheless, the aforementioned studies on sunk cost do suggest that sunk costs cannot always be assumed to be irrelevant for behavior.

3. The game

The game involves one seller and two buyers who take part in two stages of play. In the first stage, players simultaneously offer links to each other. A link is formed when both players offer it. The two buyers cannot form a link with each other. If no link is formed the game ends and all players obtain a payoff of zero. If at least one link is formed, the linked players proceed to the second stage in which they engage in a three round alternating offers bargaining with a shrinking pie. Bargaining starts with the seller simultaneously offering a share between 0 and 240 to each buyer that he is linked to, where the seller is allowed to make unequal offers to the buyers. An agreement is reached if at least one buyer accepts the offer. If both buyers accept the seller's offer, one of them is randomly chosen to trade. If no agreement is reached the game proceeds to the next round. There are at most three rounds in the bargaining and the side of the market that makes offers alternates: in the second round the buyers make offers and in the third round the seller makes offers again. The pie shrinks each round by 80 points; the first round pie is 240, the second round pie is 160, and the third round pie is 80 points. After each round all players are informed about the offers, and the acceptances. If no offer is accepted in any of the three rounds, all players receive a payoff of zero minus the link costs.

We consider two different cases that correspond to the two treatments implemented in the experiment. In the first case, links are costless; in the second, each link that is formed costs 40.[6] The cost of a link is the same for both sellers and buyers. Costs are incurred once the link is formed, not when the link is offered. All the link offers and the formed links within the group become common knowledge at the end of the first stage.

Three different types of network can be formed. In the empty network no player has a link. In a 1-link network one buyer maintains a link with the seller. In the 2-link network both buyers have a link with the seller. In the empty network each player receives a payoff of 0. The unique subgame perfect equilibrium (SPE) payoffs for the 1-link and 2-link networks are depicted in Fig. 1.

In the 2-link network, the unique SPE for the seller is to offer 0 to both buyers in the first round, and for buyers to accept the offer.[7] This can be seen by backward induction. In the third round, the seller offers 0 to both buyers and both

[5] An exception is Güth and Schwarze (1983) who auctioned the rights to play the ultimatum game experiment as either a proposer or a responder; they found that the winning proposers were greedier than was usually the case in standard ultimatum game experiments. It is not clear though whether this is due to a selection of the auction or due to the price paid by the auction winner.

[6] Note that the equilibrium payoff to the buyer is 80 in the 1-link network and 0 in the 2-link network. We choose to set the cost of a link halfway between these two equilibrium payoffs in order to make the linking decision a salient one for the buyers.

[7] Uniqueness of the SPE in our game applies if offers can be varied continuously. In the experiment offers vary discretely with increments of 1 point. This means that strictly speaking there are multiple SPE. In the SPE mentioned in the main text the accepting side in a round is indifferent between accepting and rejecting the equilibrium offer. There are also SPE in which the accepting side is offered one point more and has a strict preference to accept.

buyers accept the offer. So the seller gets 80 and the buyers get 0. In the second round, the (Bertrand) competition between the buyers induces both of them to offer 160 to the seller and the seller accepts one of the offers. In the first round, the seller offers 0 to both buyers, and both buyers accept the offer.

In a 1-link network it is the unique SPE for the seller to propose 80 to the buyer in the first round and for the buyer to accept the offer. Again this follows by backward induction. In the third round, the seller offers 0 to the buyer, and the buyer accepts the offer. In the second round, the buyer has to offer 80 for the seller to accept the offer and hence both get 80. In the first round then, the seller has to offer 80 for the buyer to accept the offer. So, the resulting payoff is 160 for the seller and 80 for the buyer.

Given the SPE payoffs of the bargaining stage, the Nash equilibria of the link formation stage depend on the cost of a link.[8] When links are costless, all networks can be supported as a Nash equilibria.[9] No player has an incentive to unilaterally break a link, in neither the 1-link nor the 2-link network. Moreover, in case a buyer does not offer a link, the seller is indifferent between offering and not offering a link to that buyer. The same holds for the buyers. Hence, any network is supported by a Nash equilibrium. When the link costs are 40, the empty network and the two 1-link networks are established as Nash equilibria of the link formation stage. The 2-link network, however, is not supported as a Nash equilibrium because a buyer improves his payoffs from −40 to 0 by deleting his link with the seller. There is also a mixed strategy equilibrium if the link costs are 40 in which both buyers offer the seller a link with probability 0.5, and the seller offers a link to both buyers. The expected payoffs in this equilibrium are 100 and 0 for the seller and buyers, respectively.

Requiring the equilibrium networks to be (trembling hand) perfect eliminates weakly dominated strategies. When links are costless, only the 2-link network can be supported as a perfect equilibrium because the seller weakly prefers to offer links to both buyers and both buyers are weakly better off by offering a link to the seller. When the link costs are 40, the empty network is not perfect since the seller weakly prefers to offer a link to both buyers and a buyer is weakly better off by offering a link to the seller. The two 1-link networks are perfect, as is the mixed strategy equilibrium in which the buyers offer a link with probability 0.5.

On the basis of this standard equilibrium analysis we formulate the following hypotheses regarding behavior in the first stage (link formation) of the game and the second stage (bargaining) of the game.

1. **Link formation.**
   - 1a. *The seller offers two links irrespective of the link costs.*
     Offering two links is a weakly dominant strategy for the seller irrespective of whether the link costs are 0 or 40.
   - 1b. *The buyers are less likely to offer a link when link costs are* 40.
     If link costs are 0, it is weakly dominant strategy for the buyers to offer a link to the seller. If the link costs are 40, only one buyer offers a link to the seller, or both do so with probability 0.5.
   - 1c. *The* 2*-link network is formed less often when link costs are* 40.
     The 2-link network can be supported both as a Nash and as a perfect equilibrium when the link costs are 0, but the 2-link network cannot be supported as a Nash nor as a perfect equilibrium when the link costs are 40. Moreover, the only perfect equilibria in pure strategies for the cost-0 and cost-40 cases lead to the 2-link and 1-link networks, respectively.
2. **Bargaining.**
   - 2a. *Offers do not depend on the link costs.*
     Offers depend on whether a 1-link or 2-link network is formed, but conditional on the network the offers in the bargaining stage are independent of the link costs.
   - 2b. *Rejecting an offer does not depend on the link costs.*
     The decision to accept or reject an offer is not affected by the link costs since the link costs have been incurred once the bargaining stage is reached.

We now show that social preferences might lead the link costs to have an effect on the bargaining outcomes contrary to the hypotheses on bargaining formulated above. In particular, we examine the predictions of inequality aversion (Fehr and Schmidt, 1999). This model assumes that a player's utility decreases in the absolute difference between his own payoff and the payoffs of other players. The link costs may affect the difference between players' payoffs which in return may affect the bargaining outcomes. It is straightforward but somewhat tedious to derive the SPE predictions for the bargaining stage when players are inequality averse. Appendix B gives more details.

The analysis reveals that for a wide range of parameter values the link costs affect the bargaining strategies. The effect depends in particular on the aversion of the seller to advantageous inequality. If the seller is sufficiently averse to earning more than the buyers, she will want to make an equitable offer that minimizes the inequality between her net payoff and that of the buyers. This implies that, given that a 2-link network forms, link costs will positively affect the seller's first

[8] Obviously, Nash equilibria of the network formation stage constitute subgame perfect equilibrium of the complete game (network formation plus bargaining). Since subgame perfection has no bite in the network formation stage we skip the qualifier 'subgame perfection' when we analyze the equilibria of this stage of the game.

[9] When we refer to networks, we refer to formed links and disregard unilateral link offers. Obviously, networks in which a buyer offers a link whereas the seller does not offer a link to this buyer do not constitute Nash equilibria.

Table 1
The effect of link costs on the seller's first round offer.

	1 link	2 links
Standard preferences	No effect	No effect
High aversion to advantageous inequality by seller	No effect	Negative
Low aversion to advantageous inequality by seller	Negative	No effect

round offer. The seller will offer less to the buyers when there are link costs compared to the case without link costs, since she will compensate herself for the extra link costs she incurred. To be precise, an offer of 120 will minimize the net payoff difference between the seller and the buyers in the absence of link costs; an offer of 100 will do so if the seller pays link costs of 80 while the buyers each pay 40.[10] In case a 1-link network forms, the seller and the buyer incur the same like costs so there is no need for the seller to adjust her offer.

If the seller is not very averse to advantageous inequality, there will still be an effect of link costs on bargaining outcomes, but now only in case a 1-link network forms. Specifically, in this case the seller makes a lower offer to the buyer if there are link costs compared to the case without link costs. If the link costs are 40, the buyer in the link accepts lower offers since he dislikes the fact that his payoff when rejecting an offer (−40) will be lower than the payoff of the unlinked buyer (0). Anticipating this, the seller offers less to the buyer in the cost-40 case than in the cost-0 case. Note though that if the linked buyer does not care how his payoff compares to the payoff of the unlinked buyer, then the link costs are predicted not to have an effect on the offers if a 1-link network.

If a 2-link network is formed, an aversion to inequality by the buyers has no effect on the bargaining outcome. The reason is that the competition between them will induce the buyers to offer the whole pie to the seller in the second round which by backward induction implies that the buyers accept any offer of the seller in the first round irrespective of the link costs.

Table 1 summarizes the standard theoretical predictions regarding the effect of link costs on the seller's first round offer along with the alternative predictions based on inequality aversion.[11]

4. Experimental design

The experiments were conducted at the CentERlab in Tilburg University, the Netherlands. A total of 105 subjects participated in 6 sessions, and each subject participated only once. Subjects were recruited through email lists of students interested in participating in experiments. There were in total 54 subjects in 3 sessions in the cost-0 treatment, and 51 subjects in 3 sessions in the cost-40 treatment. Subjects were at tables separated by partitions, such that they could not see other participants' screens but could see the experimenters in front of the room. Sessions lasted between 70 and 95 minutes, and average earnings were approximately 18.55 Euros (16.92) including a show-up fee of 7.5 Euros in the link cost-0 (40) treatment.

First, written instructions were given to the participants and read out loud by the experimenter. A copy of the instructions is included in Appendix A. It was explained in the instructions that each group consisted of 3 players who were randomly selected at the beginning of the experiment and that the group composition was randomly changed in every period (strangers design). Subjects had no way of knowing which of the other participants were in their group. In the instructions and the experiment, the sellers were denoted as Player 1, and buyers were denoted as Player 2 or Player 3. Player roles remained fixed throughout the experiment. The game was explained as consisting of two parts: the first being about offering links to other players and the second about sharing an amount of points. Subjects were informed that the task would be repeated for 30 periods and that their final earnings comprised of the total points they earned in the experiment converted at a rate of 0.5 (0.7) Eurocents per point in the cost-0 (40) treatment plus the show-up fee. In the cost-40 treatment, it was emphasized that offering a link is not costly, but that if a link is formed players who have the link each pay 40 points. After the instructions were finished, subjects played one practice period with full feedback in order to familiarize them with the procedure, the screens, and the determination of the payoffs. Subjects' understanding of the task was then assessed by asking them 3 questions to answer at their own pace. Their answers were checked one by one and when necessary the task and the payoff structure were explained again privately.

The experiment was programmed and conducted with the software *z*-Tree (Fischbacher, 2007).[12] Each period started with a screen with the three boxes with labels 1, 2, and 3, representing the players of the group. An example of the subject screen is contained in the instructions of the experiment in Appendix A. A player's own box was always presented on top

[10] The point predictions of the symmetric, linear inequality aversion model serve to illustrate the comparative statics, but should not be taken literally. Previous studies on bargaining have shown that the predictive accuracy of the inequality aversion model is served by allowing for heterogeneity (Fehr and Schmidt, 1999), non-linear preferences (Bellemare et al., 2008), and decision errors. To allow for the latter Fischbacher et al. (2003) combine inequality aversion with Quantal Response Equilibrium (McKelvey and Palfrey, 1995, 1998).

[11] Some of the comparative statics of the inequality aversion model may also be generated from other social preference models, such as a concern for equity. These models, however, are less easy to apply than the inequality aversion model of Fehr and Schmidt (1999). For example, equity theory (Gantner et al., 2001) proposes that output be divided proportional to input, but it is not so clear what a player's input is in our game. Another alternative is the model by Bolton and Ockenfels (2000). This model requires all payoffs to be non-negative which, however, they are not in our game.

[12] The program of the experiment is available from the authors upon request.

Table 2
Average link offers per period.[a,b,c]

	Seller	Buyers
Cost-0	0.93 (0.05)	0.99 (0.01)
Cost-40	0.63 (0.09)	0.98 (0.01)
p	0.05[b]	0.13[c]

[a] Analysis takes sessions as the unit of observation; $N = 3$ for each treatment; standard deviations are in parentheses.
[b] 2-tailed ranksum test.
[c] 1-tailed ranksum test.

of the screen. Players simultaneously decided with whom to link, and they offered a link by clicking on the box of another player. Buyers could not link to each other. Subjects saw an arrow pointing to the other player's box when they clicked, and it was possible to undo the link offer by clicking again. When the players moved to the next screen,[13] a line between two players on the screen informed them about the links that were formed. If a link was offered unilaterally this was indicated with an arrow pointing to the other player.

If one link or two links were formed, the group proceeded to the bargaining stage in which the seller offered a share between 0 and 240 points to the linked buyer or buyers. If there were two links, the offers could be different for the two buyers. Then, buyers were informed about the offer or offers that the seller made, and buyers simultaneously decided whether to accept or reject the offer. If an offer was accepted, the bargaining ended and the offer was implemented. If both buyers accepted the offer, one of them was randomly chosen by the computer for the payoff realization. If both buyers rejected the seller's offer, the group proceeded to the second round of bargaining in which the buyer(s) offered a share between 0 and 160 to the seller. If the seller rejected the offer(s), they proceeded to the third and final round, in which the seller offered a share between 0 and 80 to the buyer(s). After each bargaining round, all players were informed about the acceptance and rejection decisions of their group members even when they did not have a link. At the end of bargaining, the players were informed about their own payoff in that period, their group members' payoffs in that period, and their own cumulative payoffs. In the cost-40 treatment, their total payoff was the amount of points from an agreement minus the link costs. Note that players could earn negative payoffs in this treatment. All groups in a session started each period at the same time. Thus it was not possible to identify one's group members at any point of the experiment. At the end of the experiment participants were paid privately and separately in an adjacent room.

5. Results

Unless stated otherwise, statistics treated the average of all observations in a session as one independent observation. This means that we had 3 independent observations in the cost-0 treatment and 3 independent observations in the cost-40 treatment. The p-values reported for between-treatment comparisons were based on the Mann–Whitney test; p-values reported for within-treatment comparisons were based on the Wilcoxon matched-pairs signed ranks test. We used a one-sided (two-sided) test when the corresponding theoretical hypothesis was (was not) directional.

5.1. Link formation

Table 2 depicts the average link offers per period as a function of costs and player role. The second column of the table is the average number of links the seller offered to each buyer per period. The third column states the average number of links each buyer offered to the seller. The last row shows the p-values from the comparison of the link offers across the two treatments.

In the cost-0 treatment the seller offered an average of 0.93 links to each buyer per period, which was significantly higher than the average 0.63 links to each buyer in the cost-40 treatment. So, contrary to the standard theoretical prediction 1a, the seller offered less than two links in both cost treatments, and the number of links offered by the seller was significantly lower if there were link costs.

Table 2 shows that the buyers offered on average 0.99 and 0.98 links to the seller in the cost-0 and cost-40 treatment, respectively. These averages were not significantly different. Hence, contrary to the standard theoretical prediction 1b, both buyers almost always offered a link to the seller in both cost treatments.

Table 3 depicts the relative frequencies of the number of links, and the average number of links in a period per treatment. The '0 links' column shows that there were few periods with no links. The percentage of 2-link networks was, as anticipated in theoretical prediction 1c, significantly higher in the cost-0 treatment (85.2%) than in the cost-40 treatment (25.0%). Consequently, the percentage of 1-link networks was significantly higher in the cost-40 (74.1%) than in the cost-0 treatment (14.4%). The average number of links per group was 1.85 in the cost-0 treatment and 1.24 in the cost-40 treatment. This result also confirms the direction of change that is predicted by the standard theory.

[13] The subjects moved to the next phase of the experiment when all group members pressed the OK button. Also, each screen had a binding time limit of 180 seconds in the first 5 periods, and 60 seconds in the later periods.

Table 3
Average frequency and number of links.[a,b,c]

	0 links	1 link	2 links	Average number of links
Cost-0	0.4 (0.3)	14.4 (7.4)	85.2 (7.6)	1.85 (0.08)
Cost-40	0.9 (0.3)	74.1 (15.0)	25.0 (15.3)	1.24 (0.16)
p	0.10[c]	0.025[b]	0.025[b]	0.025[b]

[a] Analysis takes sessions as the unit of observation; $N = 3$ for each treatment; standard deviations are in parentheses.
[b] 1-tailed ranksum test.
[c] 2-tailed ranksum test.

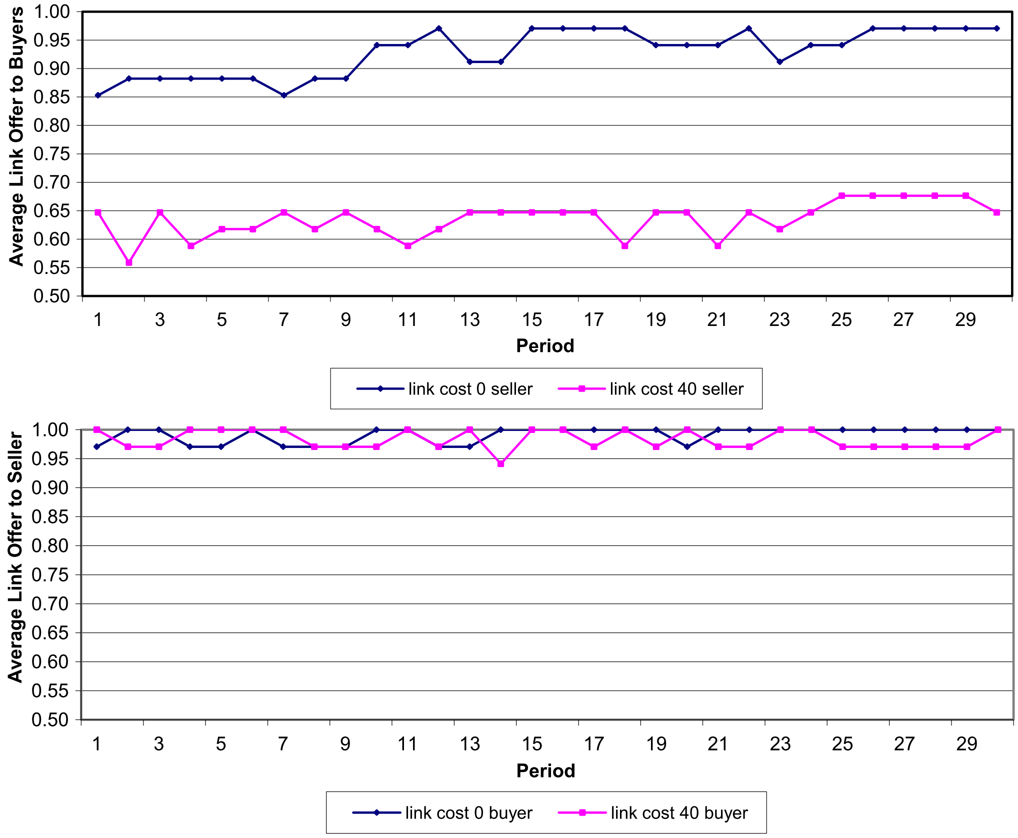


Fig. 2. Average link offers in the cost-0 and cost-40 treatments for the seller (top panel) and the buyers (bottom panel) as a function of period.

To examine how the link offers develop over time, Fig. 2 depicts the average link offers of the seller (top figure) and the buyers (bottom figure) per period in the cost-0 and cost-40 treatments. The figure shows that in the cost-0 treatment the seller's average link offer was between 0.85 and 0.97 across periods whereas in the cost-40 treatment the seller's average link offer was between 0.56 and 0.68. There is an increasing trend in the cost-0 treatment, but no clear trend in the cost-40 treatment. The buyers' average link offer varied between 0.94 and 1 across periods (bottom figure). Overall, the linking strategies of the buyers are close to 1 and do not display any development over time.

To sum up, the effect of the link costs on the average number of links was as predicted by the standard theory but the predictions on the link offers of the seller and the buyers were not supported. Because the buyers almost always offered a link to the seller in both treatments, it was due to the seller offering fewer links in the cost-40 treatment that the average number of links was lower in the cost-40 treatment. We will come back to this in the discussion.

5.2. Bargaining

Table 4 presents average offers of the first, second, and third round bargaining conditional on the network (1 link or 2 links) and conditional on the treatment (cost-0 or cost-40). The last row presents statistical tests of the differences between the two treatments.[14]

[14] Although the p-values are reported, there were not enough cases to make a statistically powerful comparison in the case of two links in the second and third rounds of the bargaining stage.

Table 4
Average offer per round.[a,b,c]

	First		Second		Third	
	1 link	2 links	1 link	2 links	1 link	2 links
Cost-0	97.50	80.43	66.11	74.04	17.25	–
	(5.49)	(1.68)	(3.33)	(5.71)	(3.18)	
Cost-40	100.53	55.45	67.23	81.40	41.93	20
	(4.82)	(1.33)	(4.21)	(1.98)	(13.88)	(–)
p[c]	0.827	0.049	1.00	0.12	0.08	–

[a] The analysis takes averages per session as the observations; $N = 3$ for each treatment.
[b] Standard deviations are in parentheses.
[c] 2-tailed ranksum test.

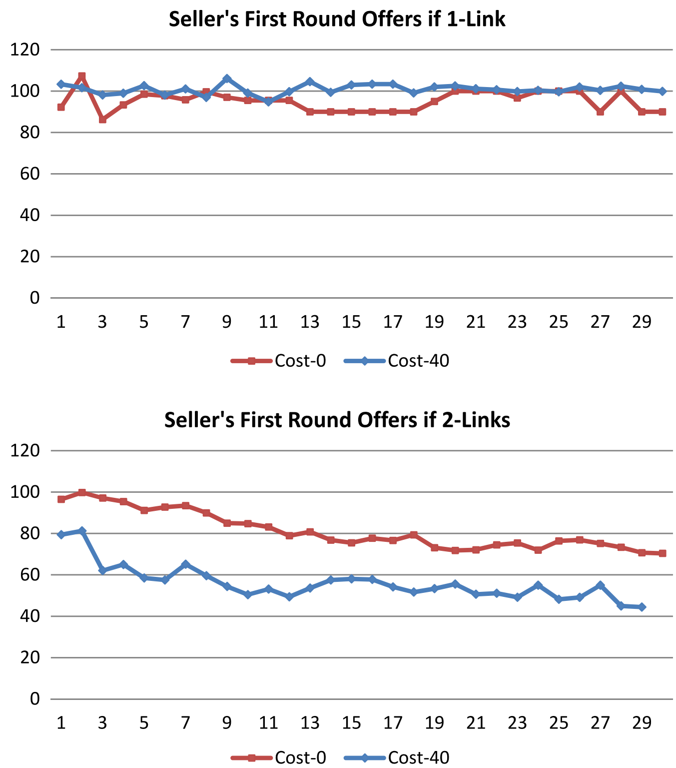


Fig. 3. Average first round offers conditional on link costs and number of links.

Note that the average offer in the first round was higher in the 1-link than in the 2-link network for both cost treatments; 97.50 vs. 80.43 ($p = 0.054$ 1-tailed signed rank test) for cost-0 and 100.53 vs. 55.45 ($p = 0.054$ 1-tailed signed rank test) for cost-40. Hence, as predicted by standard theory, competition between the buyers reduced the seller's first round offer. Nevertheless, the point prediction was quite far off the mark for the 2-link case. The seller was predicted to offer 0 in the first round, whereas the average observed offer was much above that level in both treatments.

As depicted in the second column of Table 4, the average first round offer of the seller in the 1-link network was not significantly different between the cost-0 treatment (97.50) and the cost-40 treatment (100.53), in line with hypothesis 2a. However, in contrast to this hypothesis, the average first round offer of the seller in a 2-link network is significantly higher in the cost-0 treatment (80.43) than in the cost-40 treatment (53.45). The average second and third round offers were not significantly different at the 5% level across the treatments, as shown in columns four to seven of Table 4. It should be noted though these averages are based on substantially fewer cases than the first round offers, especially for the third bargaining round where in some sessions there were no cases at all.

To sum up, link costs did not affect bargaining outcomes in a dyad, but did have a negative effect on the average offer of the seller in a triad. Interestingly, this latter effect is in line with the alternative theoretical prediction derived from inequality aversion (see the bottom row of Table 1). We will come back to this in the discussion.

To check how the effect of link costs developed over time Fig. 3 depicts the seller's average first round offer for each period in the 1-link and 2-link networks for both cost treatments. The top panel shows that the average offers in a 1-link network did not depend much on the cost treatment. Furthermore, there was no clear time trend of the offers if a 1-link

Table 5
Seller's first round offer to the buyer(s).[a,b]

	Coefficient	*P*
Links	−14.26 (3.24)	0.007
Link costs	5.62 (3.49)	0.168
Link costs × Links	−31.43 (3.36)	< 0.0001
Period	−0.02 (0.12)	0.901
Period × Links	−0.86 (0.12)	0.001
Period × Link costs	0.05 (0.13)	0.716
Constant	95.33 (2.49)	0.008

[a] The variable Links is 0 if in a dyad, and 1 in a triad; Link costs are 0 in the cost-0 treatment, and 1 in the cost-40 treatment; Period is normalized to the actual period minus 15.5.
[b] Linear regression with robust standard errors at the session level between parentheses; 1611 observations in 6 clusters.

Table 6
Buyer decision to accept the seller's first round offer.[a,b]

	Coefficient	*p*
Offer	0.074 (0.014)	< 0.001
Links	2.431 (0.264)	< 0.001
Link costs	0.549 (0.394)	0.163
Link costs × Links	0.128 (0.444)	0.772
Period	−0.008 (0.012)	0.488
Period × Links	0.067 (0.022)	0.003
Period × Link costs	0.022 (0.021)	0.286
Constant	−5.586 (1.233)	< 0.001

[a] The variable Links is 0 if in a dyad, and 1 in a triad; Link costs are 0 in the cost-0 treatment, and 1 in the cost-40 treatment; Period is normalized to the actual period minus 15.5.
[b] Logistic regression with robust standard errors at the session level between parentheses; 1611 observations in 6 clusters.

network was formed. For the 2-link networks, on the other hand, the seller's first round offer showed a clear downward trend. At the same time, the seller's first round offer was substantially higher in the cost-0 treatment than in the cost-40 treatment and there was no sign for this difference to become smaller or larger over time.

Table 5 reports the results of a linear regression that combines the various effects on the seller's first round in a multivariate analysis.[15] As can be seen, the number of links had a significant negative effect on the seller's first round offer. Link costs did not have a significant effect, but the interaction effect with the number of links did; reiterating the finding that link costs reduced the seller's offer only in case of a 2-link network. Finally, the period number had a significantly negative effect on the seller's offer only in case of 2-links.

Next we analyze buyers' acceptance decisions in the first bargaining round. Since the decision to accept or reject depends on the seller's offer, we need to control for this offer. To test our theoretical prediction that rejecting an offer does not depend on the link costs (hypothesis 2b) we ran logistic regressions for the first round acceptance decisions of the buyers. We report the results of the model in Table 6.

Notice first that the effect of the seller's offer was positive and highly significant. From the marginal effects (not reported in the table) we can infer that an increase of the offer by 10 points was associated with an increase of the acceptance probability of 5%. The effect of the number of links was positive and significant; controlling for the level of the offer the acceptance probability was 29% higher in the 2-link network than in the 1-link network. Importantly, the effect of link costs on the probability of accepting an offer was positive but not significantly so. The interaction effect between the link costs and the number of links was also positive, indicating that link costs had a somewhat larger effect in case of 2 links, but this effect was not significant either. These results do not refute hypothesis 2b; rejecting an offer does not seem to depend on the link costs. Finally, the period number had a positive effect on the acceptance probability only in the 2-link network.

Summing up the results on bargaining, we found a significant positive effect of the link costs on the seller's average first round offer, but only in case a 2-link network was formed. Link costs, however, did not have a significant effect on the buyers' acceptance behavior. So, again it was the seller's behavior rather than the buyers' that shaped the effect of the link costs.

Finally, it is informative to examine the average payoffs of the players in the two treatments, both conditional and unconditional on the network. Table 7 shows the average net payoffs of the seller and the buyer as well as the average payoffs for the 1-link and 2-link network separately. The p-values in the fifth column correspond to the tests comparing the

[15] In a 2-link network the sellers could made a different offer to one buyer than to the other buyer; in fact they did so in 52% of the cases. For the regressions we took the average of the two offers as the dependent variable in those cases.

Table 7
Average net payoffs per period.[a,b]

	Seller				Buyers			
	Average	1 link	2 links	P^d	Average	1 link	2 links	P^d
Cost-0	150.61	124.37	155.89	0.054	41.88	48.48	41.21	0.054
	(7.14)	(11.41)	(3.90)		(0.55)	(3.61)	(0.90)	
Cost-40	88.40	86.88	98.08	0.054	19.35	29.92	−11.25	0.054
	(6.87)	(6.83)	(4.08)		(8.16)	(3.30)	(1.38)	
p^c	0.025	0.025	0.025		0.025	0.025	0.025	

[a] The analysis takes averages per session as the observations; $N = 3$ for each treatment.
[b] Standard deviations are in parentheses.
[c] 1-tailed ranksum test.
[d] 1-tailed signed ranks test.

earnings of the sellers in the 1-link network to the earnings of the seller in the 2-link network within each cost treatment. Likewise, the p-values in the last column correspond to the tests comparing the earnings of the buyers.

The seller earned on average 150.61 in the cost-0 treatment, which was significantly higher than the average earning of 88.40 in the cost-40 treatment. Note that the average earning of the seller in the cost-0 (cost-40) treatment was 89 (32) points smaller than the theoretical prediction. The seller also earned less than the predicted 160 (240) points in the 1-link (2-link) network.

There were three reasons why the seller's earnings were substantially lower than those predicted by standard theory. First, contrary to the theoretical predictions, 1-link networks were formed in 14.4% of the periods in the cost-0 treatment (see Table 3), which decreased the seller payoffs. Second, sellers' first round offers were much higher than predicted in case there were two links (see Table 4). In both treatments, sellers offered more than 55 in the first round if there were two links, whereas they were predicted to offer 0. The third reason was the rate at which buyers rejected seller's first round offer. In the cost-0 treatment 23% of the offers were rejected in the first round in the 1-link network whereas in the 2-link network *both* buyers rejected the seller's offer in 2% of the cases. In the cost-40 treatment, the percentage of rejections in the first round was 13% in the 1-link and 5% in the 2-link network.[16]

6. Discussion

The standard theory successfully predicts that fewer links will be formed in the presence of higher link costs and that the rejection of an offer by a buyer is independent of link costs. However, in our experiment we observed two results on the effect of link costs that cannot be easily explained by standard theory: (i) the seller determined which type of network was formed, and (ii) the link costs did affect the offers of the seller in a 2-link network.

Theory predicts that, on average, only one buyer offers a link to the seller in the cost-40 treatment. Why did the buyers almost always offer a link to the seller in this treatment? The answer is that it paid off to do so. As indicated in Table 7, buyers' average earnings were 19.35 in the cost-40 treatment, which is higher than the payoff of 0 a buyer would receive in case he would not offer a link. So, the real puzzle is why the sellers offered so few links in the cost-40 treatment relative to the cost-0 treatment. Again a closer inspection of the net payoffs may provide a hint.

Table 7 shows that in both treatments the seller's average payoffs were higher with 2 links than with 1 link and the reverse holds for the buyers. Specifically, in the cost-0 treatment the seller earned 31.52 more on average in a 2-link network (155.89) than in a 1-link network (124.37), whereas the buyers on average earned 7.27 less $(48.48 - 41.21)$. Taking these payoffs as given, by "moving" from a 1-link to a 2-link network the seller earned an extra 31.52 while the payoff inequality increased by 38.79 $(31.52+7.27)$. In the cost-40 treatment these figures are markedly different. The seller earned 11.20 more on average in a 2-link network (98.08) than in a 1-link network (86.88), and the buyers earned 41.17 less $(29.92-(-11.25))$ which means that payoff inequality increased by 53.37 points $(11.20 + 41.17)$. Taking the payoffs in the different networks as given, a seller with a concern for advantageous inequality would find the 2-link network less attractive relative to the 1-link network in the cost-40 treatment than in the cost-0 treatment.[17] This may have been a reason for the seller to opt for the 2-link network less frequently in the cost-40 treatment than in the cost-0 treatment.

A disutility from advantageous inequality on the part of the seller may also explain why the seller's average first round offer in the 2-link network was higher in the cost-0 treatment than in the cost-40 treatment, as argued in Section 3 (see Table 1). If the seller wishes to reduce the difference between her net payoff and that of the buyers she needs to offer less to the buyers in the cost-40 treatment than in the cost-0 treatment. After all, the seller incurs the link costs twice in the 2-link network, which already reduces the advantage of the seller over the buyers.

Recall that the acceptance behavior of the buyers was not affected by the link costs (see Table 6). This again is in line with the hypothesis that the effect of link costs in the 2-link network is mainly driven by the seller's disliking of

[16] In the cost-0 treatment in the 2-link network 13% of the offers were rejected in the first round by *at least one* buyer. In the cost-40 treatment, in the 2-link network 20% of the offers were rejected in the first round by at least one buyer.
[17] The same holds for sellers with a concern for efficiency or fairness.

advantageous inequality rather than the buyers' disliking of disadvantageous inequality. But why does aversion to disadvantageous inequality of the buyers not lead to lower offers in the 1-link networks of the cost-40 treatment compared to the cost-0 treatment? One possible explanation is that buyers are concerned about the payoff difference with the seller but not so much about the payoff difference with the other buyer. As outlined in Section 4, it is the latter concern that drives the hypothesized effect of link costs in the 1-link networks. If the linked buyer in a 1-link network does not mind that in case of rejection he will earn −40 whereas the unlinked buyer will earn 0, then the hypothesized effect of link cost in the 1-link network disappears (see Appendix B).

An issue we have not yet discussed is that players are likely to be heterogeneous in their aversion to inequality (Fehr and Schmidt, 1999). An implication is that sellers who opt for a 1-link network need not have the same preferences as those who opt for a 2-link network. Specifically, in the cost-40 treatment a seller with a high aversion to advantageous inequality is more likely to choose for a 1-link network than a seller without such an aversion. An indication for self-selection in the data is that linking behavior of the sellers in the cost-40 treatment was very heterogeneous. In the cost-40 treatment, 67% (12/18) of the sellers rarely offered two links during the 30 periods, whereas 22% (4/18) almost always did; only 11% (2/18) of the sellers alternated several times between offering one link and offering two links.[18] Clearly, self-selection can have strengthened the impact of link costs on bargaining outcomes in the 2-link networks. After all, in the cost-40 treatment, sellers with a low aversion to inequality are more likely to choose for a 2-link network, whereas in the cost-0 treatment the average offer to buyers is higher because more sellers are present with high aversion to inequality.

Finally, we would like to mention that an earlier version of this paper was based on experimental data using the same design with a partners matching rather than a strangers matching.[19] It is useful to briefly compare the results of the two matching protocols. The linking results were very similar. The buyers almost always offered a link and the seller offered two links much less frequently in the cost-40 treatment than in the cost-0 treatment. The main difference was in the effect of the link costs on the bargaining outcomes. With partners matching, the seller's average first round offers in a 2-link network did not depend on the link costs. The seller's average first round offer in the 1-link network, however, was significantly higher in the cost-40 treatment than in the cost-0 treatment. Note that this effect is opposite to that predicted by inequality aversion. The effect can be explained by the fact that the implicit threat by the seller to switch from a 1-link network to a 2-link network in the next period was less credible in the cost-40 treatment than in the cost-0 treatment. This explanation relies on the game being repeated with the same seller and buyers. The finitely repeated game has many more equilibria than the one-shot game (Doğan, 2011). This makes a partners design less suited than a strangers design to test the equilibrium predictions of a one-shot game, as was our aim in this paper.

7. Conclusion

The results of this study show that link costs can play a dual role in markets and other settings that require connections to be established between transacting agents. First, link costs shape the competitiveness (power distribution) of the network, which in turn strongly influences the outcomes. Second, link costs have an effect on the bargaining within a network. Such costs cannot simply be assumed to be sunk, once a network has been formed. In other words, the interaction within a network cannot be assumed to be independent from the formation of the network.

The effect of link costs on bargaining outcomes is subtle. There is a significant effect of link offers on the seller's offers if a 2-link network is formed but not if a 1-link network is formed. This effect can be explained by the presence of an aversion to advantageous inequality on the part of the seller. In a 1-link network, the seller and the linked buyer both pay for the link, so the presence of link costs affects them in the same way. In contrast, in a 2-link network the seller pays twice as much for the links than each of the two buyers. If the seller cares sufficiently for equality, she will compensate herself for the extra link costs and offers less to the buyers than she does in the absence of link costs.

Models of social preferences can explain that link costs matter given a particular shape of the network. However, social preference can also affect the formation of the network itself. For instance, if a seller prefers to equally divide the surplus between herself and her contracting buyer, then there is no reason for her to form a competitive network in the first place. In particular if forming links is costly, a less competitive network will save on link costs and still allow an equitable outcome to be established. Taking this argument one step further by allowing for heterogeneous social preferences, implies that less competitive networks are more likely to be established by inequality averse and fair-minded hosts than are very competitive networks. In other words, self-selection may strengthen the effect that link costs exert on the ensuing interaction that takes place within an endogenously formed network.

This in fact also hints at an interesting option for future research, which is to study the effect of link cost on bargaining outcomes in networks that are formed exogenously and compare these to the case of endogenous networks. This would allow for an assessment of the relative strength of the different channels through which social preferences may drive the impact of link costs on bargaining outcomes.

[18] Self-selection is not much of an issue in the cost-0 treatment since all sellers except one offered two links in most of the periods, especially towards the end of the experiment.

[19] We thank the associate editor and the referees for inviting us to run the strangers design.

Appendix A. Experimental instructions for the cost-0 treatment

Introduction

Welcome to this experiment on decision making. We will first go through the instructions together. Then there will be a practice period. After the practice period the experiment will start. Talking is strictly forbidden during the experiment. If you have a question, please raise your hand and I will come to your table to answer your question.

The experiment will last about 2 hours. If you follow the instructions carefully you can earn a considerable amount of money. During the experiment your earnings will be denoted in points. After the experiment your earnings will be converted into money at a rate of 1 point is 0.5 Eurocents. In addition, you will receive a show-up fee of 7.5 Euros. Your earnings will be paid to you, privately and in cash, immediately after the experiment.

Instructions for the experiment

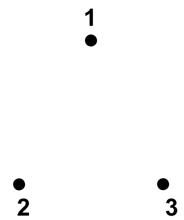
In this experiment, you are either player 1, player 2, or player 3. Your player number is randomly determined at the beginning of the practice period and it stays the same throughout the whole experiment. The experiment consists of 30 periods. In every period, groups of three persons are formed, each consisting of player 1, player 2, and player 3. The composition of your group will be randomly determined in every period. So, your player number (1, 2, or 3) remains the same over all 30 periods, but the composition of your group will change every period. You will not know who is in your group.

You face the same task for 30 periods. The task has two parts. First, you make a decision about whether to offer links to other players in your group or not. Second, players who form a link to each other try to share an amount of points between them.

In the first part a link is formed between two players if both of them offer a link to each other. Player 1 can have two links; player 2 and 3 can have only one. Hence player 2 and player 3 each have to decide whether they want to offer a link to player 1. Player 1 has to decide whether to offer a link to player 2 and whether to offer a link to player 3. Offering a link is not costly. Also, links that have formed are not costly.

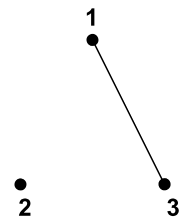
There are 4 different types of situations that can arise from the players' decisions to offer links to other players.

Situation A:



In Situation A there are no links. This occurs when player 1 and player 3 do not both offer a link to each other, and player 1 and player 2 do not both offer a link to each other.

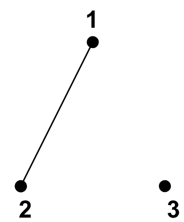
Situation B:



In Situation B there is only one link, namely between player 1 and player 3.

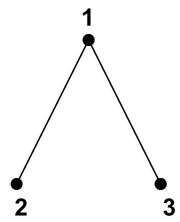
This occurs when both player 1 and player 3 offer a link to each other, while player 1 and player 2 do not both offer a link to each other.

Situation C:

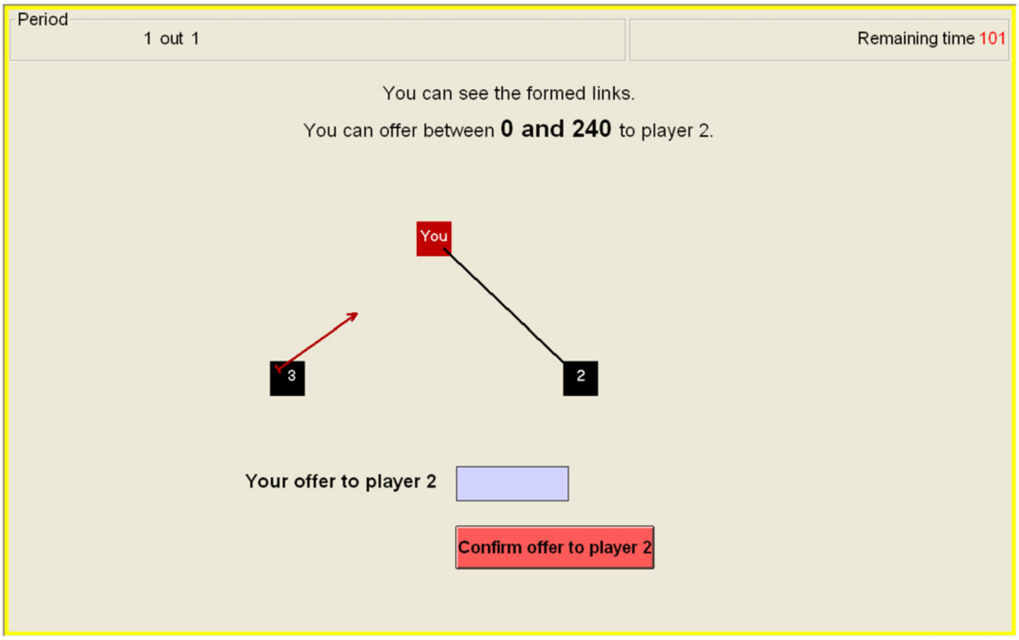


In Situation C there is only one link, namely between player 1 and player 2. This occurs when both player 1 and player 2 offer a link to each other, while player 1 and player 3 do not both offer a link to each other.

Situation D:



In Situation D there are two links: one link between player 1 and player 3, and one link between player 1 and player 2. This occurs when both player 1 and player 2 offer a link to each other and also both player 1 and player 3 offer a link to each other.



The figure above illustrates how the results of the first part of the period are displayed to you on the computer screen. A black line indicates that both players offered a link to each other. A red arrow indicates that one player offered a link but the other player did not offer a link to that one player. So, in this example the black line indicates that player 1 (which is "You" in this case) and player 2 offered a link to each other and as a result a link is formed between them. The red arrow indicates that player 3 offered a link to player 1 while player 1 did not offer a link to player 3. Therefore no link is formed between player 1 and player 3.

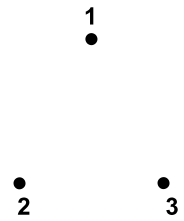
After the first part, if a link or links are formed, your group proceeds to the second part of the period. If no links are formed in the first part all members of your group receive zero points and they proceed to the next period. In the second part, two players who have a link to each other try to share a certain amount of points among the two of them. The second part has at most 3 stages. There are two aspects of the second part that change in each stage; the amount of points to be shared and the player or players that can make an offer.

Let us first focus on the amount of points to be shared in each of the three stages. In the first stage, the amount of points that two players can share is 240. If no two players agree on how to share the 240 points, they proceed to the second stage. In the second stage, the amount of points that can be shared is reduced by 80 points, from 240 to 160 points. If no two players agree on how to share the 160 points in the second stage, they proceed to the third and final stage. In the third stage, the amount of points that can be shared is again reduced by 80 points, from 160 to 80 points. If no two players agree on how to share the 80 points in the third stage, then the period ends and all players earn 0 points in that period.

Let us now focus on which player or players that can make an offer in each of the three stages. In the first stage player 1 offers a share to the players that s/he has links with. In the second stage player 2 and/or player 3 offer a share to player 1. In the third stage player 1 offers a share to the players that s/he has links with.

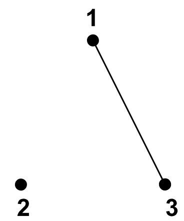
To explain the procedure in the second part in more detail, now we again go through each of the situations that can arise in the first part.

Situation A:

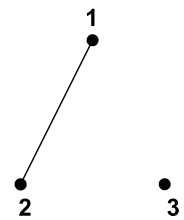


Since no links have formed in Situation A, players cannot share points. Hence, the period is over and all players earn 0 points.

Situation B:



Situation C:



Consider first Situation B in which there is one link, namely between player 1 and player 3. Recall that there are at most 3 possible stages.

First stage

- In the first stage player 1 offers between **0 and 240** to player 3.

Keep in mind that an offer always means the amount of points **offered to** the other player. So, player 1 offers an amount of points to player 3; thus, player 1 demands **240 − offer** for herself/himself.

- Player 3 sees player 1's offer and decides to accept or to reject player 1's offer.
  - If player 3 accepts player 1's offer, the period is over and they share the 240 points as offered by player 1.
  - If player 3 does not accept player 1's offer, they proceed to the second stage.

Second stage if reached

- In the second stage player 3 offers between **0 and 160** to player 1.
- Player 1 sees player 3's offer and decides to accept or to reject player 3's offer.
  - If player 1 accepts player 3's offer, the period is over and they share the 160 points as offered by player 3.
  - If player 1 does not accept player 3's offer, they proceed to the third stage.

Third stage if reached

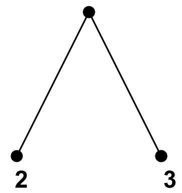
- In the third stage player 1 offers between **0 and 80** to player 3.
- Player 3 sees player 1's offer and decides to accept or to reject player 1's offer.

- ◦ If player 3 accepts player 1’s offer, they share the 80 points as offered by player 1.
- ◦ If player 3 does not accept player 1’s offer, they both earn 0 points.

Situation C is similar to Situation B except that instead of player 3, now player 2 has a link to player 1.

Let us now turn to the final situation, Situation D.

Situation D:



In Situation D there is a link between player 1 and 3 and a link between player 1 and 2. It is important to realize that at most one pair of players can form an agreement on how to share the points.

First stage

- In the first stage, player 1 offers between 0 and 240 to player 3 and to player 2. The offers to player 3 and player 2 can be different.
- Players 2 and 3 see player 1’s offers. Players 2 and 3 decide to accept or to reject player 1’s offer.
  - ◦ If both player 2 and player 3 accept player 1’s offer, the computer ***randomly chooses*** player 2 or player 3. If player 3 is chosen, then player 1 and player 3 share the 240 points as offered by player 1, and player 2 earns 0 points. If player 2 is chosen, then player 1 and player 2 share the 240 points as offered by player 1, and player 3 earns 0 points.
  - ◦ If either player 2 or player 3 accepts player 1’s offer and the other player rejects, then the player that accepts and player 1 share the 240 points as offered by player 1. Let’s assume player 2 accepted player 1’s offer and player 3 rejected. Then player 1 and player 2 share the 240 points as offered by player 1, and player 3 earns 0 points.
  - ◦ If both players 2 and 3 reject player 1’s offer, they proceed to the second stage.

Second stage if reached

- In the second stage, player 2 and player 3 offer between 0 and 160 to player 1.
- Player 1 sees player 2’s and player 3’s offers. Player 1 decides to accept one of the offers, or to reject both offers.
  - ◦ If player 1 accepts one of the offers, then the player whose offer was accepted and player 1 share the 160 points as offered. Let’s assume player 1 accepted player 3’s offer. Then player 1 and player 3 share the 160 points as offered by player 3, and player 2 earns 0 points.
  - ◦ If player 1 rejects both offers, they proceed to the third stage.

Third stage if reached

- In the third stage, player 1 offers between 0 and 80 to player 3 and to player 2. The offers to player 3 and player 2 can be different.
- Players 2 and 3 see player 1’s offers. Players 2 and 3 decide to accept or to reject player 1’s offer.
  - ◦ If both player 2 and player 3 accept player 1’s offer, the computer ***randomly chooses*** player 2 or player 3. If player 3 is chosen, then player 1 and player 3 share the 80 points as offered by player 1, and player 2 earns 0 points. If player 2 is chosen, then player 1 and player 2 share the 80 points as offered by player 1, and player 3 earns 0 points.
  - ◦ If either player 2 or player 3 accepts player 1’s offer and the other player rejects, then the player that accepts and player 1 share the 80 points as offered by player 1. Let’s assume player 2 accepted player 1’s offer and player 3 rejected. Then player 1 and player 2 share the 80 points as offered by player 1, and player 3 earns 0 points.
  - ◦ If both players 2 and 3 reject player 1’s offer, players 1, 2 and 3 earn 0 points.

To summarize:

In every period, you will be in a group of 3 persons. Each person will have her or his own number; 1, 2, or 3. Your number will be randomly determined at the beginning of the practice period and it will stay the same throughout the experiment. The groups are formed randomly in every period, so the composition of your group will change from one period to the next. You will not know who is in your group in any period.

There will be 30 periods in the experiment. In every period there will be two parts. First, you will decide with whom to link. Second, at most one pair of linked players shares an amount of points. The important points of the experiment are the following:

- A link is formed between two players if both of them offer a link to each other.
- Player 2 and player 3 cannot form a link with each other.
- Only two players who have a link with each other can try to share a certain amount of points among themselves.
- In the second part of the period, there are at most 3 stages. In the first stage the amount to be shared is 240; in the second it is 160; in the third it is 80.
- In the first stage player 1 can make an offer, in the second stage player 2 and/or player 3 can make an offer, and in the third stage player 1 can make an offer. If there is no agreement in the third stage, everyone gets 0 points.
- At most one pair of players can reach an agreement in a period. When there are two links and if both players 2 and 3 accepts player 1's offer, either player 2 or player 3 is chosen randomly by the computer to form an agreement with player 1.
- In each period you will be informed about all the decisions made by your group members. At the end of each period, you will be informed about your and other players' earnings.
- Your total earnings will be the sum of all points you earn over all periods. For each point you earn in the experiment, you will get 0.5 Eurocents.

Appendix B. Bargaining predictions with inequality aversion

In this appendix we illustrate that the standard prediction – that link costs do not affect bargaining – may change when players have the following utility function:

$$U_i = x_i - \frac{\alpha}{2}\sum_{j\neq i}\max(x_j - x_i; 0) - \frac{\beta}{2}\sum_{j\neq i}\max(x_i - x_j; 0)$$

where the monetary payoffs are denoted by x_i, $i = 1, 2, 3$. Parameter α (β) measures a player's disutility from earning less than (more than) another player. It is assumed that $\alpha \geqslant \beta$ and $0 \leqslant \beta < 1$, and for simplicity it is assumed that these parameters are common knowledge and the same for all players. Furthermore, it is assumed that players compare their own payoff to the payoffs of all other players, i.e., including the non-trading buyer.

We distinguish between two cases, depending on the degree to which the players are averse to advantageous inequality.

(a) $\beta > 2/3$

In this case, the seller is more concerned about reducing inequality with the buyers than about earning more money: $\partial U_1/\partial x_1 = 1 - \beta < \partial U_1/\partial x_j = \frac{1}{2}\beta$, as long as $x_1 > x_j$, for $j = 2, 3$. This means that the seller wants to make an offer in the first round (s_1) that equates her payoff with the payoff of the buyer she trades with. With $c \in \{0, 40\}$ denoting the link costs and $L \in \{1, 2\}$ the number of links, net payoffs are equated if:

$$240 - s_1 - Lc = s_1 - c$$

Solving for s_1 gives:

$$s_1 = 120 - \frac{1}{2}c(L - 1)$$

It follows that s_1 decreases with c if and only if $L = 2$.

(b) $\beta < 2/3$

In this case, the seller is more concerned about earning more money than about reducing inequality. This means that the seller will set the offer as low as possible, subject to the constraint that the offer is accepted by the buyer(s). We analyze the 1-link and the 2-link network in turn.

(i) 1-link network

To solve for the subgame perfect equilibrium (SPE), we start with the third bargaining round.

Third round. Assume (as will turn out to be correct in equilibrium) that the seller offers less than half of the remaining pie of 80 to the linked buyer: $s_3 < 40$. This implies that we need to analyze the case $c = 0$ and the case $c = 40$ separately because in the former case the linked buyer will earn more than the unlinked buyer, whereas in the latter case the linked buyer will earn less than the unlinked buyer.

Case $c = 0$. If the buyer accepts offer s_3, his utility is

$$s_3 - \frac{\alpha}{2}(80 - s_3 - s_3) - \frac{\beta}{2}(s_3 - 0)$$

If the buyer rejects the offer, his utility is 0. It follows that the buyer will reject if

$$s_3 < \frac{80\alpha}{2 + 2\alpha - \beta}$$

In equilibrium, the seller will make an offer just equal to the acceptance threshold.

Case $c = 40$. If the buyer accepts offer s_3, his utility is

$$s_3 - 40 - \frac{\alpha}{2}\big(80 - 40 - s_3 - (s_3 - 40)\big) - \frac{\alpha}{2}\big(0 - (s_3 - 40)\big)$$

If the buyer rejects the offer, his utility is $-40 - \frac{\alpha}{2}(0 - (-40))$. It follows that the buyer will reject if

$$s_3 < \frac{80\alpha}{2+3\alpha}$$

Hence, the buyer's acceptance threshold is smaller in case $c = 40$ than in case $c = 0$. The reason is that in the former case the buyer dislikes the fact that he will earn less than the unlinked buyer in case he would reject the seller's offer.

Second round. If the seller accepts the buyer's offer s_2, her utility is (assuming $c < s_2 < 80$)

$$s_2 - c - \frac{\alpha}{2}\big(160 - c - s_2 - (s_2 - c)\big) - \frac{\beta}{2}(s_2 - c - 0)$$

If the seller rejects the offer, her utility is

$$80 - c - s_3 - \frac{\beta}{2}\big(80 - c - s_3 - (s_3 - c)\big) + \frac{\beta}{2}(80 - c - s_3 - 0)$$

Hence, the seller will reject if

$$s_2 < \frac{80(1+\alpha-\beta) - s_3(1-\frac{3}{2}\beta)}{1+\alpha-\frac{1}{2}\beta}$$

In equilibrium, the buyer will make an offer just equal to this acceptance threshold. Since $\beta < 2/3$ this threshold is decreasing in s_3.

First round. If the buyer accepts offer s_1, his utility is (assuming $c < s_1 < 120$):

$$s_1 - c - \frac{\alpha}{2}\big(240 - c - s_1 - (s_1 - c)\big) - \frac{\beta}{2}(s_1 - c)$$

If the buyer rejects offer s_1, his utility is:

$$160 - c - s_2 - \frac{\beta}{2}\big(160 - c - s_2 - (s_2 - c)\big) - \frac{\beta}{2}(s_2 - c)$$

It follows that the buyer will reject offer s_1 if

$$s_1 < \frac{80(2-2\beta+\frac{3}{2}\alpha) - s_2(1-\frac{3}{2}\beta)}{1+\alpha-\frac{1}{2}\beta}$$

In equilibrium, the seller will make an offer just equal to this acceptance threshold. Since $\beta < 2/3$ this threshold is decreasing in s_2.

Combining the results of the three rounds, we find that in the unique subgame perfect equilibrium of the 1-link network the seller's third round offer (s_3) is decreasing in the link cost (c), which implies that the buyer's second round offer (s_2) is increasing in the link costs, which implies that the seller's first round offer is decreasing in the link costs.

(ii) 2-link network

Irrespective of the seller's offer (s_3) in the third and final round of bargaining, both buyers will offer the full pie to the seller in round 2 ($s_{2,j} = 160$, $j = 2, 3$). Each buyer always has an incentive to slightly overbid the other buyer since by doing so he will surely trade with the seller and will prevent having a lower payoff than the other buyer (see Proposition 2 in Fehr and Schmidt, 1999). For round 1 there are now two equilibria. One in which both buyers accept any offer, and the seller offers them nothing ($s_1 = 0$). In the other equilibrium, both buyers reject low offers. Specifically, a buyer will reject an offer s_1 (assuming that the other buyer will reject the offer) if the utility of rejection exceeds the utility of acceptance:

$$-c - \frac{\alpha}{2}\big(160 - c - (-c)\big) > s_1 - c - \frac{\alpha}{2}\big(240 - 2c - s_1 - (s_1 - c)\big) - \frac{\beta}{2}\big(s_1 - c - (-c)\big)$$

that is, if

$$s_1 < 80\frac{\alpha}{2+2\alpha-\beta}$$

In equilibrium the seller will make an offer at this lower bound, which, as we see, is independent of c.

Table B1 summarizes the comparative statics of the link costs.

Recall that in the analysis above it was assumed that the players consider the payoffs of all other players. If, however, the seller and the trading buyer only compare their payoffs to each other and do not care about the non-trading buyer, then the results change as follows. (a) The effect of link costs in the 1-link network disappears. Recall that this effect is driven by the disutility the linked buyer experiences from earning less than the unlinked buyer in case he were to reject the seller's offer in the third round. (b) The threshold value of β that distinguishes between the two main cases decreases from $\beta = 2/3$ to $\beta = 1/2$. The reason is that the weight attached to advantageous inequality with the trading buyer is increased. The seller will now aim to equalize payoffs with this buyer already when $\beta > 1/2$.

Table B1
The effect of link costs on the seller's first round offer.

	1 link	2 links
Standard preferences: $\alpha = \beta = 0$	0	0
Inequality aversion: $\alpha \geqslant \beta$ and $0 \leqslant \beta < 2/3$	–	0
Inequality aversion: $\alpha \geqslant \beta$ and $2/3 < \beta < 1$	0	–

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