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TRADING INFORMATION GOODS ON A NETWORK: AN EXPERIMENT

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Trading information goods on a network: An experiment*

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Abstract

We experimentally examine the impact of a cycle path on the trading of a copyable information good in networks. A cycle path in a network permits a buyer to become a reseller that can compete against existing sellers by replicating the good. Theory predicts that the price of the information good, even with the first transaction where there is not yet a reseller competing with the original seller, will be lower in networks with a cycle path than otherwise. However, our experiment reveals that the observed price for the first transaction is significantly higher in networks with a cycle path.

Keywords: Information good, Network

JEL codes: D42, L14

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1 Introduction

When information (such as images, videos, texts, computer programs, and technological innovation) is consumed and benefits consumers, it is defined as an information good. Information goods, unlike ordinary goods, do not disappear when consumed and can be easily copied. Given this property of being copyable, every successful transaction of the information good creates a new seller and thus may negatively affect any benefit to its originator. Indeed, noting that information goods are typically exchanged bilaterally in a network,[1] Polanski (2007) and Manea (2021) show that when information goods are traded in such a way, the distribution of benefit among the parties involved may greatly differ depending on the network structure, namely, whether the network has a cycle path.

A cycle path is a set of network links in which the starting and ending points are on the same node. On the one hand, if there is no cycle path, the seller can enjoy a greater benefit because the resale of information by the buyer would not introduce competition between the buyer and the seller. On the other hand, if a cycle path exists, the act of the buyer reselling the good results in competition between the seller and the buyer. As a result, the seller's benefit will be much less (and that for the buyer much more) than without a cycle path. Moreover, the benefit on the buyer side extends upstream, even to the first transaction where no resale competitor to the originator yet exists, because the market participants foresee price competition in the future.

[1] For example, when founded in 1999, Napster allowed users to transfer their digital audio files bilaterally through its peer-to-peer system.

In this paper, we experimentally verify these theoretical implications. Namely, we pose the following research questions:

1. Are prices lower in a network with a cycle path compared with one without?

2. Does the effect of competition with the latter transaction extend upstream to the first transaction?

To address these, we set up an experiment in which players trade information goods in networks. We consider two simple networks, one with a cycle path and the other without, of three players, originally consisting of one seller (i.e., the originator) and two buyers, and compare the behavior of the players across the two networks.

Our main finding is that the prices observed in the network with a cycle path are inconsistent with theory compared with those observed in the network without a cycle path. Specifically, although competition between the originator and the reseller lowers the observed prices in the final transaction in the network with a cycle path, its magnitude is much smaller than that predicted by theory. In addition, contrary to theory, the prices for the first transaction tend to be higher in the network with a cycle path.

Moreover, we reveal that learning does not resolve the gap between theory and the experimental results in the network with a cycle path. Instead, it could widen the discrepancy in the prices of the first transaction. This is because as participants gain experience by repeatedly playing the game, the prices of the first transaction in the network with a cycle path could rise further given the increasing willingness of buyers to buy the good, which is inconsistent with theory.

Our study contributes to the literature on information goods and the network economy, for which there are many early studies concerning the buying and selling of information goods. For example, Admati and Pfleiderer (1986, 1990) analyzed the trading of information in financial markets, while Raith (1996) presented a model in which information sharing in an oligopolistic market arises in equilibrium. Elsewhere, Talor (2004) analyzed the customer information market for Amazon and other Internet companies, and Bergemann et al. (2018) addressed information trading from the viewpoint of mechanism design.

Many studies that focused on the characteristic that information goods can be copied were related to copyright. For instance, Liebowitz (1985) and Basen and Kirby (2005) analyzed how the presence or absence of copyright affects social benefits and those of the original information supplier, and Varian (2005) and others conducted copyright research focusing on the digitization of information. However, Muto (1986), Takeyama (1994), and others conducted research focusing on the externality of information, that is, the collapse of monopoly as information spreads.

To this body of work, Polanski (2007) introduced graph theory and created a model in which information is traded through negotiations between players linked in a network, revealing that the information externalities depend on the structure of the network. Later, Manea (2021) extended the theory by Polanski (2007) by defining the equilibrium that holds in more general situations. As noted above, their key finding is that the distribution of gains is affected by whether the network containing the seller and the buyer has a cycle path.

Unlike existing experimental studies, our experiment deals with information good in the network economy. For instance, Gale and Kariv (2009) investigated the case in which assets were traded through a network and found that the transaction prices converged to competitive prices. Choi et al. (2017) investigated path competition in their network experiment and found that the position of a node greatly affects the gain. However, unlike these studies, our experiment focuses on the price competition in the trading of an information good in a network with a cycle path. In this setting, a seller inevitably creates a resale competitor when selling the good given its replicable property.

The remainder of the paper is organized as follows. Section 2 summarizes the main theoretical results of the model to be tested in the experiment. Section 3 discusses the experimental design and procedure. We summarize the data in Section 4, followed by the results of the main analyses in Section 5. Section 6 concludes.

2 Theory

In this section, we explain the theoretical results of the model to be verified in the experiment according to Polanski (2007) and Manea (2021).

2.1 Network Theory Preliminary: Tree Network and Cycle

The network consists of nodes and links. Let $N = \{1, 2, .., n\}$ be the set of nodes in the network. The existence of a connection, or the link, between nodes i and j $(i, j \in N)$ is represented by h_{ij}. If the link exists, $h_{ij} = 1$, and otherwise, $h_{ij} = 0$. We assume the network is undirected, that is, $h_{ij} = h_{ji}$ for all i, j. Let H be an $n \times n$ matrix whose (i, j) element is h_{ij}. A network G is defined as the set of nodes N and the link matrix H, $G = (N, H)$.

We use the notation ij for the link between i and j. A path connecting nodes i and j in a network is a sequence of nodes $\{i_0, i_1, .., i_{\bar{k}}\}$, where $i_0 = i$,$i_{\bar{k}} = j$, $h_{i_k i_{k+1}} = 1$ for all $k \in \{0, 1, .., \bar{k} - 1\}$. A cycle is a path in which the first and last nodes are the same $i_0 = i_{\bar{k}}$, and from i_0 to $i_{\bar{k}-1}$ are all different nodes.

A connected component of G is a subnetwork of G induced by any maximal set of nodes that are mutually connected by paths in G. A network is connected if it has a single connected component. A connected network that does not contain any cycle is called a tree. In this paper, the network without cycle paths is a Tree, and the network with cycle paths is a Cycle.

2.2 Model

Figure 1 depicts the simplest three-node networks we use to assess the difference between a Tree (left) and a Cycle (right). Player 1 is connected to Players 2 and 3 in both the Tree and Cycle. While Players 2 and 3 are not connected with each other in the Tree, they are connected in the Cycle.

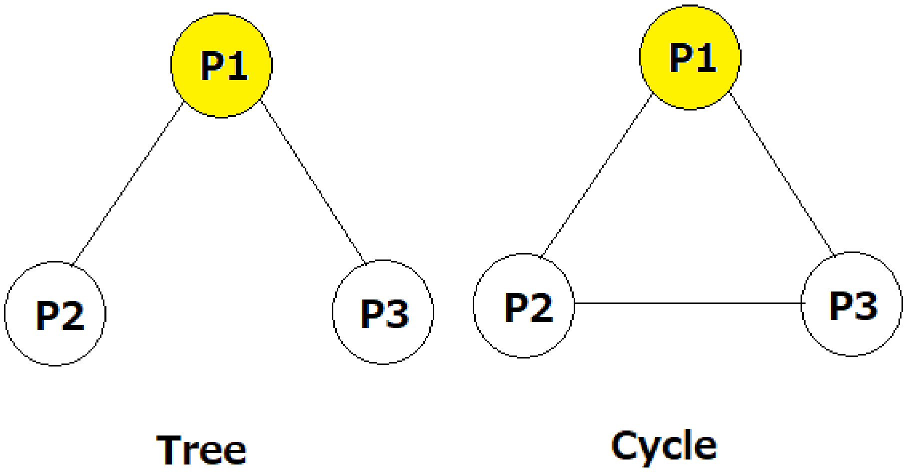


Figure 1: Tree and Cycle

As mentioned earlier, Player 1 is the originator of the information good, hence the sole seller at the start of the game. Player 1 gains payoff only by selling the good to buyer players. Buyer players (i.e., Players 2 and 3) gain a payoff of 100 from obtaining and consuming the good. Moreover, in the Cycle, they can copy the information good and sell it to the buyer player that does not yet possess the good. If the resale transaction is successful, they earn additional resale benefit. Therefore, in the Cycle, competition between the originator and a reseller could take place.

We assume, as in Polanski (2007), that at most one transaction occurs per period between a connected seller and buyer. If there are multiple trading possibilities, one link is randomly selected with equal probability. Players at each end of the selected link then negotiate over the transaction price. We assume that a Nash bargaining solution determines the transaction price in which the market power of the seller is α and that of the buyer is $1 - \alpha$.

$\alpha \in (0, 1)$ is an exogenous variable.

In our experiment, the game is terminated with a probability of $1 - \delta$ when negotiation fails. This ensures that the experiment concludes within a reasonable time. As a result, the equilibrium payoffs are subject to the continuation probability δ.

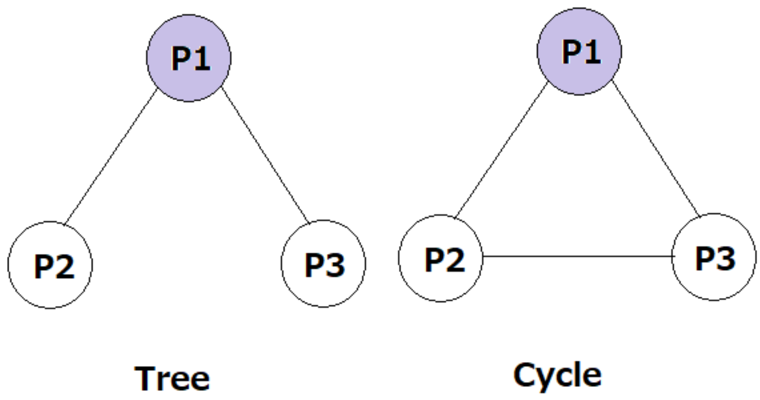
2.3 Equilibrium Payoff

The equilibrium payoffs are defined by the state of the network at the time of the transaction. In our three-person network model, these are described by two states, "Stage 1" and "Stage 2."

Stage 1 is a state in which Player 1 is the only player owning the information, as shown in the top panel of Figure 2. The game starts in this state. Stage 2 is a state in which one transaction is completed from Stage 1. As a result, either Player 2 or 3 possesses the information in addition to Player 1. The bottom panel of Figure 2 displays the case in which Players 1 and 2 possess the good, and which is known to Player 3. If a further transaction is completed in this state, all players in the network will own the information, and the game ends. Therefore, the network is always in a state of either Stage 1 or 2 in the middle of the game.

We denote the ex post (i.e., after the link for the current negotiation is selected) expected payoff of the game by $x^n_{st,r}$, where $n = C, T$ (Cycle, Tree), $st = 1, 2$ (Stage 1, Stage 2), $r = s, b$(seller, buyer). As the Stage 1 payoffs are derived via backward induction from Stage 2 as shown below, the Stage 1 payoffs include the Stage 2 expected payoffs.

Stage 1 - Only Player 1 owns the good.



Stage 2 - Two players own the good.

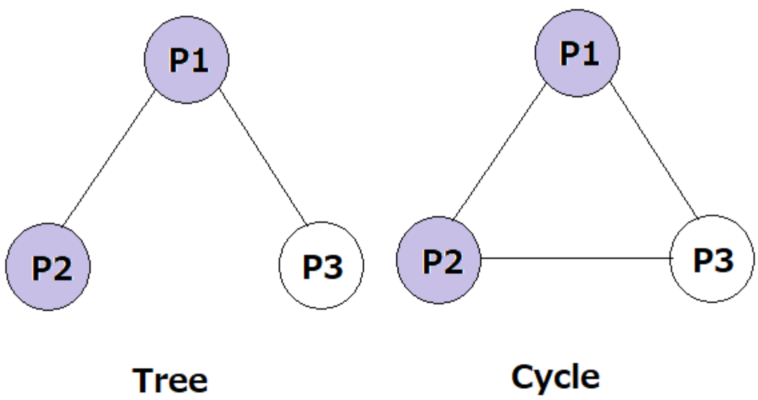


Figure 2: Two States in the Game

The equilibrium payoffs are derived following the formulation of Polanski (2007). The expected payoff is defined by the state of the network. The equilibrium expected payoff is the value obtained by allocating the surplus generated from the transaction to the threat point payoff according to available market power. We also assume that the player is rational. That is, when a transaction produces a positive (negative) total surplus, the probability of the success of the transaction is 1 (0). To avoid multiple equilibria, we assume that the transaction surplus is positive in each negotiation.

2.3.1 Stage 2 Payoff in Cycle

In Stage 2 of the Cycle, the threat points in the negotiation are δx_{2b}^C for the buyer and $\frac{1}{2}\delta x_{2s}^C$ for the seller. This is because if negotiation fails, while the buyer player becomes a buyer again in the next negotiation for certain, the seller player is selected as the next seller only with the probability $\frac{1}{2}$. We assume that the seller earns no gain if not selected as the seller in the next negotiation and the buyer purchases the good from the other seller player.[2] If the transaction is completed, a total gain of 100 is divided between the two players. Therefore, the following equations hold.

$$x_{2s}^C = \frac{1}{2}\delta x_{2s}^C + \alpha(100 - \frac{1}{2}\delta x_{2s}^C - \delta x_{2b}^C) \tag{1}$$

$$x_{2b}^C = \delta x_{2b}^C + (1-\alpha)(100 - \frac{1}{2}\delta x_{2s}^C - \delta x_{2b}^C) \tag{2}$$

Eqs. (1) and (2) represent the equilibrium conditions for the seller and

[2] Given the total surplus is positive, the next negotiation succeeds with probability 1. The same argument applies below.

the buyer, respectively. Using the total gain equation ($x_{2s}^C + x_{2b}^C = 100$) and Eq. (1) or (2), the Stage 2 payoffs are derived as follows.

$$x_{2s}^C = \frac{100(1-\delta)\alpha}{1-\frac{1}{2}\delta-\frac{1}{2}\alpha\delta} \tag{3}$$

$$x_{2b}^C = \frac{100(1-\alpha)(1-\frac{1}{2}\delta)}{1-\frac{1}{2}\delta-\frac{1}{2}\alpha\delta} \tag{4}$$

2.3.2 Stage 1 Payoff in the Cycle

If a negotiation fails in Stage 1, the buyer player will be the buyer again in the next negotiation with the probability $\frac{1}{2}$. Otherwise, the player will be the buyer in Stage 2, premising that the other buyer purchases the good in the next negotiation and the game proceeds to Stage 2. The seller becomes the seller in the next negotiation again for certain.

If a negotiation is successful, in addition to the 100 generated by the resulting transaction, either the seller or the buyer of this negotiation will become the seller player in the next negotiation in Stage 2 and will earn x_{2s}^C, which occurs with probability $\frac{1}{2}$ for each. Therefore, the following equations hold.

$$x_{1s}^C = \delta x_{1s}^C + \alpha(100 + \frac{1}{2}x_{2s}^C + \frac{1}{2}x_{2s}^C - \delta x_{1s}^C - \frac{1}{2}\delta x_{1b}^C - \frac{1}{2}\delta x_{2b}^C) \tag{5}$$

$$x_{1b}^C = \frac{1}{2}\delta x_{1b}^C + \frac{1}{2}\delta x_{2b}^C + (1-\alpha)(100 + \frac{1}{2}x_{2s}^C + \frac{1}{2}x_{2s}^C - \delta x_{1s}^C - \frac{1}{2}\delta x_{1b}^C - \frac{1}{2}\delta x_{2b}^C) \tag{6}$$

Eqs. (5) and (6) represent the equilibrium condition for the seller and the buyer, respectively. Using the total gain equation ($x_{1s}^C + x_{1b}^C = 100 + x_{2s}^C$) and

Eq. (5) or (6), Stage 1 payoffs are derived as follows.

$$x_{1s}^C = \{1-\delta+\frac{1}{2}\alpha\delta\}^{-1}[\alpha(1-\frac{1}{2}\delta)(100+x_{2s}^C)-\frac{1}{2}\delta\alpha x_{2b}^C] \tag{7}$$

$$x_{1b}^C = \{1-\delta+\frac{1}{2}\alpha\delta\}^{-1}[(1-\alpha)(1-\delta)(100+x_{1s}^C)+\frac{1}{2}\delta\alpha x_{2b}^C] \tag{8}$$

2.3.3 Stage 2 Payoff in a Tree

For the case of Stage 2 in the Tree network, even if the transaction fails, the same transaction is repeated. Thus, the following equations hold.

$$x_{2s}^T = \delta x_{2s}^T + \alpha(100-\delta x_{2s}^T-\delta x_{2b}^T) \tag{9}$$

$$x_{2b}^T = \delta x_{2b}^T + (1-\alpha)(100-\delta x_{2s}^T-\delta x_{2b}^T) \tag{10}$$

Eqs. (9) and (10) represent the equilibrium conditions for the seller and the buyer, respectively. Using the total gain equation ($x_{2s}^T + x_{2b}^T = 100$) and Eq. (9) or (10), Stage 2 payoffs are derived.

$$x_{2s}^T = 100\alpha \tag{11}$$

$$x_{2b}^T = 100(1-\alpha) \tag{12}$$

2.3.4 Stage 1 Payoff in a Tree

If a negotiation fails in Stage 1, the buyer player of the current negotiation will become the buyer again in the next negotiation with probability $\frac{1}{2}$. Otherwise, the player will be the buyer in Stage 2, premising that the other buyer purchases the good in the next negotiation and the game proceed to Stage 2. The seller player of the failed negotiation becomes the seller again for certain in the next negotiation.

If a negotiation is successful, in addition to the 100 generated by this transaction, the seller of the negotiation will be the seller in Stage 2 for certain and will earn x^T_{2s}. Therefore, the following equations hold.

$$x^T_{1s} = \delta x^T_{1s} + \alpha(100 + x^T_{2s} - \delta x^T_{1s} - \frac{1}{2}\delta x^T_{1b} - \frac{1}{2}\delta x^T_{2b}) \tag{13}$$

$$x^T_{1b} = \frac{1}{2}\delta x^T_{1b} + \frac{1}{2}\delta x^T_{2b} + (1-\alpha)(100 + x^T_{2s} - \delta x^T_{1s} - \frac{1}{2}\delta x^T_{1b} - \frac{1}{2}\delta x^T_{2b}) \tag{14}$$

Eqs. (13) and (14) represent the equilibrium conditions for the seller and the buyer, respectively. Using the total gain equation ($x^T_{1s} + x^T_{1b} = 100 + x^T_{2s}$) and Eq. (13) or (14), the Stage 1 payoffs are as follows.

$$x^T_{1s} = \{1 - \delta + \frac{1}{2}\alpha\delta\}^{-1}[\alpha(1 - \frac{1}{2}\delta)(100 + x^T_{2s}) - \frac{1}{2}\delta\alpha x^T_{2b}] \tag{15}$$

$$x^T_{1b} = \{1 - \delta + \frac{1}{2}\alpha\delta\}^{-1}[(1-\alpha)(1-\delta)(100 + x^T_{1s}) + \frac{1}{2}\delta\alpha x^T_{2b}] \tag{16}$$

2.4 Equilibrium Price

The equilibrium price in each stage is computed from the abovementioned expected payoff. Let p^n_{st} be the transaction price of Stage st ($st = 1, 2$) and network type n ($n = C, T$). The analytical solutions are as follows.

$$p_1^C = \{1 - \delta + \frac{1}{2}\alpha\delta\}^{-1}[100\alpha(1 - \frac{1}{2}\delta) - (\frac{1}{2} - \alpha)(1 - \delta)x_{2s}^C - \frac{1}{2}\delta\alpha x_{2b}^C] \quad (17)$$

$$p_1^T = \{1 - \delta + \frac{1}{2}\alpha\delta\}^{-1}[100\alpha(1 - \frac{1}{2}\delta) - (1 - \alpha)(1 - \delta)x_{2s}^T - \frac{1}{2}\delta\alpha x_{2b}^T] \quad (18)$$

$$p_2^C = \frac{100(1 - \delta)\alpha}{1 - \frac{1}{2}\delta - \frac{1}{2}\alpha\delta} \quad (19)$$

$$p_2^T = 100\alpha \quad (20)$$

Suppose that $\delta = 0.9$ (as in our experiment) and $\alpha = 0.5$. $\alpha = 0.5$ is a reasonable benchmark case where the power of negotiation is equal between the seller and the buyer, both anonymously matched in the experiment. Then, the equilibrium prices are $p_1^C \approx 26.04$ and $p_1^T \approx 42.31$ for Stage 1, and $p_2^C \approx 15.38$ and $p_2^T = 50$ for Stage 2. The Stage 2 equilibrium price in a Cycle is drastically lower than in a Tree because of competition between the originator and the reseller.[3] Moreover, the effect of competition on the price in a Cycle also appears upstream in Stage 1, in which a reseller has not yet appeared in the market. Our primary aim of the experiment is to verify these theoretical predictions for prices.

3 Experimental Design and Procedure

We conducted six sessions of computer-based online experiments in October 2020.[4] We recruited 141 subjects from a subject pool at the Institute

[3] Polanski (2007) and Manea (2021) analyze the Cycle and Tree equilibria in the case of $\delta = 1$. When $\delta = 1$, $p_1^C = p_2^C = 0$ and $p_1^T = p_2^T = 100\alpha$.

[4] The experiment was programmed and conducted with o-Tree (Chen et al., 2016), and we used Zoom (`https://zoom.us/`) to welcome and communicate with participants. After verifying their names in the waiting room, participants were given an anonymous

of Social and Economic Research, Osaka University, managed by ORSEE (Greiner, 2015). The subject pool consists of students, both undergraduate and graduate, in various fields in the university. Our subjects are paid according to their performance in the experiment. Each subject experiences 16 trials in a session, and one trial is selected randomly at the end of the experiment. The points the subject earned in the selected trial is then converted into Japanese yen (JPY) as a performance-based payment (at the rate of 40 JPY per point). In addition to the performance-based payment, our subjects were paid a participation fee of 500 JPY. Payments were in the form of an emailed Amazon gift card.

A session consists of two treatments, each consisting of eight consecutive trials, regarding the network structure, and we denote the treatment with a Tree structure as "Tree" and that with a Cycle structure as "Cycle." The experimental design is a within-subject design, whereby each subject receives both treatments successively. However, the treatment order is counterbalanced among the subjects to offset the possible order effects, with 66 subjects receiving Tree first and Cycle later. The remaining 75 subjects received these treatments in reverse order.[5] The number of subjects and the treatment order in each of the six sessions are presented in Table I.1 in OSM I.

Each treatment consists of eight consecutive trials, and a trial includes several rounds of negotiations. After the subjects read the experimental

participation ID (sub01, sub02, ..) when entering the meeting room. Their mobile cameras as well as microphones were off during the experiment.

[5]As the treatment order is counterbalanced among our subjects, the order effect should not be a major concern. Nonetheless, we assess the magnitude of the order effects in the Online Supplementary Material (OSM) II. The results indicate that the potential bias in our analysis arising from the order effect is zero, or at most marginal.

instructions and completed a few quizzes that assessed their comprehension of the rules of the game, the experiments were carried out in the following procedure.[6]

At the beginning of the first trial, the position of each subject in the network is randomly determined after considering that there is an equal number of participants in each of the three positions. This position is held constant across all 16 trials.[7]

At the start of a trial, a group of three players occupying each of the three positions is randomly formed. Player 1 is the originator of the good and the only seller at the start of every trial. For each round, one negotiable link, i.e., a link between a seller and a buyer, is selected, and a negotiation for the transaction of the good starts between the linked seller and buyer. In the negotiation, the buyer and the seller each simultaneously propose a bid and an ask once for the transaction, respectively. Then, the bid and the ask are displayed to both players. If the bid is equal to or higher than the ask, the transaction is established in the round. Otherwise, the negotiation in the round fails. If the transaction is established, the price P is determined as the middle value between the ask and the bid, and the price is announced to both players in the transaction. The seller of the transaction earns a gain of P, and the buyer earns a gain of $100 - P$. However, both players earn nothing if the negotiation fails.

[6]The experimental instructions and screenshots of the actual experiments (translated from Japanese to English) are provided in OSM VII.

[7]The position of each subject in the network is kept unchanged through the entire session, even across the two treatments, to ease the comprehension of the subjects in the game. In addition, identical positions for the players in each session enable us to control for individual heterogeneity in the statistical analysis in accordance with the within-subject experimental design.

If the transaction is established, the link between the buyer and the seller is no longer negotiable as the buyer of the transaction becomes an additional seller. If that player is linked to a remaining buyer, the link becomes negotiable, and that player could sell the information to the remaining buyer if the link is selected for negotiation hereafter in the trial. Sellers that sold the good to a buyer remain as sellers.

The round ends once the negotiation is finished regardless of its success or failure. The experiment proceeds to the next round if the negotiation is successful. In the case of failure, however, the trial is terminated with a 10% chance as discussed in Section 2.2. In the next round, a negotiable link is newly selected to start a negotiation. The same negotiable link as the previous round can be selected again. A trial also ends if all the players possess the good, and no further negotiation is needed. The final point for a subject in the trial is equal to the total points the subject has earned in the trial.

Once a trial ends, the experiment proceeds to the next trial unless the terminated trial is the final one. The members of the three-person game are rematched when a new trial begins.

4 Summary of the Data

We briefly summarize the data by overviewing the sample size, share of successful trials, the frequency of negotiations, and the payoffs. Major behavioral data for our subjects are analyzed in Section 5.

The data contains 752 trials of three-person games, which consist of 2,077

Table 1: Share of Successful Trials

Treatment	Share of Successful Trials (whole transactions)	Share of Partially Successful Trials (Stage 1 transaction)
Tree	0.822	0.931
Cycle	0.835	0.918

rounds of negotiations in total. Of the 752 trials, 623 trials (82.8%) were successful in that both buyers obtained the good. Among the remaining 129 trials, no buyer obtained the good in 57 trials, and only one buyer obtained the good in 72 trials. We refer to a trial as partially successful if at least one transaction is established. Thus, the number of partially successful trials is 695 (92.4%).

The likelihood that a trial is finished successfully is almost identical across the two treatments. As displayed in Table 1, the percentage of trials in which two whole transactions are successfully established for all three players is 82.2% in Tree and 83.5% in Cycle. The two values do not differ statistically significantly ($p - value = 0.629$). Similarly, the percentage of trials in which at least one transaction is done is 93.1% in Tree, which does not differ significantly from that in Cycle, which is 91.8% ($p - value = 0.492$ in OSM III). These results suggest that we do not need to be concerned with the unevenness of the sample failure across the two treatments due to sudden failure amid ongoing negotiations. The detailed discussion and the statistical analysis are presented in OSM III.

Table 2 presents summary statistics of the number of negotiations per

Table 2: Number of Negotiations per Trial

Treatment	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)	Pctl(95)	Max
Tree	3.579	2.062	2	3	4	7	14
Cycle	3.092	1.581	2	3	4	6	14

Note: Limited to trials in which whole transactions are established among the three players.

trial for each treatment. The average number of negotiations in Tree is 3.579, while that in Cycle is 3.092, which is statistically significantly different ($p - value < 0.01$, see OSM IV).

For the percentiles displayed in Table 2, there is little difference up to the 75 percentile. Half of the trials are concluded within three negotiations, and 75% finish within four negotiations. A slightly larger number of trials appear after the 75 percentile in Tree.

One might believe that the speed of learning about the optimal plays of the game could differ between the two treatments. Because Cycle has more complicated game rules, subjects require more time to learn the optimal plays. As a result, the dynamics of the number of negotiations could differ across the treatments. Our analyses, reported in OSM IV, do not confirm that the number of negotiations changes as our subjects gain experiences in Cycle. Moreover, our subjects also tend to negotiate more in the later trials in Tree. However, we do not find sufficient evidence that the speed of learning differs across the two treatments. In OSM IV, we also compare the numbers of negotiations across Stages 1 and 2, but we again do not find a significant difference.

Table 3: Mean Payoff of Players

Treatment	Originator	Buyer		
		Pooled	First Buyer	Last Buyer
Tree	101.560	49.220	47.702	50.738
	(15.633)	(9.588)	(9.239)	(9.704)
Cycle	78.588	60.706	68.753	52.659
	(26.400)	(20.761)	(25.650)	(8.694)

Note: Standard deviations in parentheses.

Table 3 presents the players' payoff according to the roles they are assigned in the game, that is, as originators or buyers. Buyers are further classified into two distinct types. One is a class of buyers that reached a buying agreement in Stage 1. We denote this type of buyer as "first buyer." The other is the class of buyers that finally bought the good in Stage 2. We refer to this other type of buyer as "last buyer."

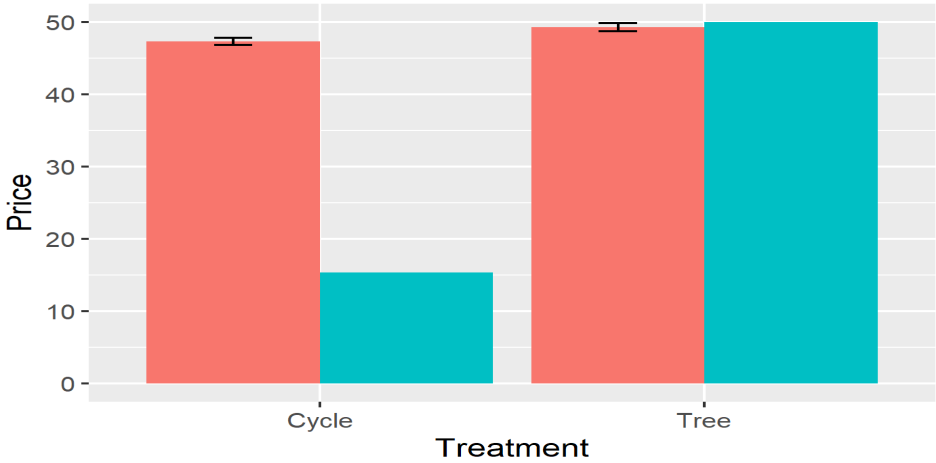
As displayed in Table 3, the mean payoff of an originator in Tree is 101.56, which is far larger than that of buyers in the treatment, which is 49.22. Roughly speaking, an originator is expected to earn twice as much as a buyer. Among the buyers, a first buyer earns nearly the same as a last buyer in Tree. The mean payoff of the former is 47.70, and that of the latter is 50.74. While the difference is small, it is statistically significant (Wilcoxon pairwise test, $p - value < 0.01$). The almost identical share of the two buyers is a straightforward result of the theory in Tree, in which any buyer is equivalently required to buy the good from the originator.

In Cycle, in which transactions between the first and last buyers can take place, originators earn less than in Tree. The mean payoff of an originator is 78.59, which is statistically significantly smaller than that in Tree (Wilcoxon pairwise test, $p - value < 0.01$). Naturally, buyers earn more in the treatment as they obtain the remainder, such that a buyer earns 60.71 on average. Among buyers, a first buyer earns 68.75 on average, which is statistically significantly larger than in Tree ($p - value < 0.01$, after controlling for individual-level fixed effects with cluster-robust standard errors). A last buyer earns 52.66 on average, which is slightly, but statistically significantly, larger than in Tree ($p - value = 0.029$, again after controlling for individual-level fixed effects with cluster-robust standard errors). The payoff of a first buyer is significantly larger than that of a last buyer in Cycle on average by 16.09 (Wilcoxon pairwise test, $p - value < 0.01$). We further discuss the payoff difference between buyers in Section 5.5.

Although the payoffs differ across the two treatments, it does not necessarily imply that the players also behave differently across the two treatments. Given a transaction between the first buyer and the last buyer is allowed in Cycle, the payoff of the originator becomes smaller in Cycle than in Tree, even if the pricing behavior of the originator (i.e., the values of the proposed asks) remains unchanged, simply because the originator now has less chance of selling as the first buyer has a chance to sell too.[8] In the following section, we focus our analysis on transaction prices, bids, and asks to address any behavioral differences among our subjects across the two treatments.[9]

[8]In addition, the standard deviation of the originator's payoff becomes larger in Cycle than in Tree simply because they have only a stochastic chance to sell the good in the treatment. Note that the standard deviations of the prices do not differ so much as shown in Figures 3 and 4 below.

[9]The only exception is the payoff of last buyers. The difference in last buyers' payoff across the two treatments necessarily implies that the behavior associated with the final transactions differs.



Note: Red: data. Green: theory. Error bars show plus-minus one-standard error range.

Figure 3: The Average Price in Stage 2

5 Prices, Bids, and Asks

5.1 Prices in Stage 2

As discussed in Section 2.3, the model is solved by backward induction. With that in mind, we first discuss the results of Stage 2, then proceed to those of Stage 1.

Figure 3 plots the mean price in Stage 2 for Tree (49.26) as well as Cycle (47.34), together with their theoretical prediction (50 and 15.38, respectively). While the mean price in Tree is not statistically significantly different from the theoretical prediction ($p - value = 0.156$), that in Cycle is far greater ($p - value < 0.01$). Instead, the mean price in Cycle is only slightly less than that in Tree, although the difference is statistically significant ($p - value < 0.01$, Model 1 in the third column in Table 4). This result suggests that the downward pressure in prices induced by competition, which manifests itself as statistical significance, is weak.

Result 1: While the Stage 2 prices in Tree are consistent with theory, those in Cycle are not, as the Stage 2 prices in Cycle are only slightly smaller than those in Tree.

Does this discrepancy between the data and theory in Cycle resolve itself as our subjects accumulate experience? This is because our subjects might not have learned the power of competition yet in the early trials of the treatment, which they might learn in the latter trials. To address this, we estimate the following linear regression, which includes variables capturing learning effects, by regressing the prices on four explanatory variables, *Cycle*, *Latter*, $Cycle \times Latter$, and a constant. *Cycle* is a dummy variable that takes a value of one if the trial belongs to Cycle, otherwise zero. *Latter* is a dummy variable that takes a value of one if the trial lies in the latter half of each treatment (i.e., the 5th to 8th trials), otherwise zero, and this captures the overall learning effects across the two treatments.

$Cycle \times Latter$ is the cross term of *Cycle* and *Latter*, which captures additional impacts on the learning effect specifically appearing in Cycle. The statistical significance of the variable suggests that learning effects differ across the two treatments (i.e., the existence of a treatment-specific learning effect). The learning effect in Tree is captured by the coefficient of the term *Latter*, and that in Cycle by the sum of the coefficients of the terms *Latter* and $Cycle \times Latter$. We also report the results of a regression in which only two regressors are included, *Cycle* and a constant, to overview the treatment effect over all trials.

Table 4: Regression Results for Price

	Dependent Variable			
	Price			
	Stage 1		Stage 2	
	Model 1	Model 2	Model 1	Model 2
Cycle	1.512**	0.698	−1.921***	−2.221**
	(0.687)	(0.973)	(0.738)	(1.039)
Cycle × *Latter*	-	1.627	-	0.656
		(1.374)		(1.470)
Latter	-	−0.971	-	−2.257**
		(0.969)		(1.044)
Const.	52.343***	52.829***	49.262***	50.373***
	(0.484)	(0.685)	(0.524)	(0.732)
Observations	695	695	623	623
R^2	0.0069	0.0101	0.0108	0.0220

*p<0.1; **p<0.05; ***p<0.01.

The results of these regressions appear under Model 2 in the fourth column of Table 4. The coefficient for the term *Latter* is −2.257, which is significant ($p - value = 0.03$), implying that the overall learning effect tends to lower prices. However, our primary focus here is the value of the coefficient for the cross term $Cycle \times Latter$, which captures the treatment-specific learning effect in Cycle. Its value of 0.656 is not significantly different from zero. This indicates that contrary to our earlier speculation, price competition between the two sellers in Cycle does not lower prices more in later trials by which time our subjects should have accumulated experience. Instead, the positive value of the point estimate, while not significant, implies that the treatment-specific effect in Cycle could have resisted the overall tendency to lower the prices observed with the coefficient for the term *Latter*. Indeed, the sum of the coefficients of the terms *Latter* and *Cycle* $\times$ *Latter*, that is, the magnitude of the learning in Cycle, is -1.601, which is not statistically significant (F-test, $p-value = 0.122$).[10]

Result 2: The price competition in Stage 2 in Cycle does not facilitate subject learning in converging to the equilibrium implied by the theory.

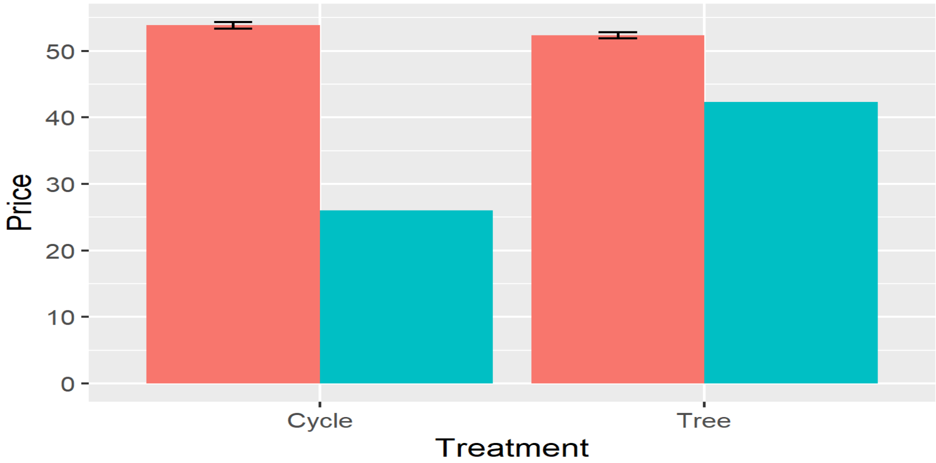
Competition is a strong power to guide economies to equilibria. For example, Roth et al. (1991) report that prices converge to a competitive equilibrium in their multiplayer market experiments. However, our results for Stage 2 suggest that the effect of competition is quite limited. Although competition between the two sellers lowers the prices in Cycle, the extent of this is far below the level implied by theory. This limited effect of competition is similar to that reported in experiments with Bertrand price competition (Dufwenberg and Gneezy, 2000; Baye and Morgan, 2004) and travelers' dilemma (Capra et al., 1999) games.

5.2 Prices in Stage 1

As our empirical findings for the prices in Stage 2 deviate from the theoretical implications for Cycle, those in Stage 1 could deviate too.

Figure 4 illustrates the mean Stage 1 prices for Tree (52.35) and Cycle (53.86), together with the theoretical predictions (42.31 and 26.04, respectively).

[10]The insignificance of the learning effect in Cycle is also confirmed, even if we employ Cycle data only ($p-value = 0.103$).



Note: Red: data. Green: theory. Error bars show plus-minus one-standard error range.

Figure 4: The Average Price in Stage 1

In Tree, the mean Stage 1 price is larger than that of Stage 2. Although the difference (3.08) is small, it is statistically significant (Wilcoxon pairwise test, $p - value < 0.01$). The mean price is statistically significantly higher than the theoretically predicted level ($p - value < 0.01$).

In Cycle, the mean price in Stage 1 is 53.86, which is larger than that in Stage 2 by 6.514 (Wilcoxon pairwise test, $p - value < 0.01$) and is also far larger than the level implied by theory ($p - value < 0.01$). This variation from the theoretical prediction is larger than that in Tree by 17.78. Thus, similar to the Stage 2 prices, we observe that the Stage 1 prices in Cycle deviate from theory, and the deviation is far larger than that in Tree.

In addition, the mean Stage 1 price in Cycle is larger than that in Tree by 1.51 ($p - value = 0.028$, Model 1 in the first column in Table 4), which is opposite to the theoretical prediction that prices should be far lower in Cycle than in Tree.

Result 3: The Stage 1 prices in Cycle deviate from theory considerably more than in Tree. In addition, again in contrast to theory, the Stage 1 prices in Cycle are even larger than the prices in Tree.

We now address whether the discrepancy between our experimental data and the theory in Cycle could be resolved by learning. Similar to the above-mentioned analysis of Stage 2, we undertake identical linear regression analysis to address the existence of a learning effect in Stage 1. The result is presented in Model 2 in the second column of Table 4. The coefficient of $Latter$ is not significantly different from zero ($p - value = 0.316$), indicating that no learning appears in Tree. Moreover, the coefficient of $Cycle \times Latter$ is also not significant ($p - value = 0.237$), suggesting that there exists no treatment-specific learning effect in Cycle. Indeed, the sum of the coefficients of the terms $Latter$ and $Cycle \times Latter$, which is only 0.656, is not significantly different from zero (F-test, $p - value = 0.502$). These results jointly indicate that there is little evidence for the existence of learning, not only in Cycle but also in Tree. Thus, as in Stage 2, there is little possibility that the discrepancy between the theory and the data in Cycle is resolved by learning in Stage 1.

Result 4: We do not observe any learning effect in the prices in Stage 1.

5.3 First Bids and Asks in Stage 1

We have obtained little evidence of subjects learning to play according to the theoretical prediction based on our analysis of prices. However, as prices are determined jointly by bids and asks, this may mask the effect of learning. We thus turn our attention to bids and asks separately.

We particularly focus on the bids and asks proposed in the first negotiations of each trial because they carry uncontaminated information. The first bids and asks are proposed before the player observes any behavior of the other players in the trial[11]; thus, they are considered to directly reflect the player's initial prospects for the prices in the trial.[12] Here we focus our analysis on the first bids and asks in Stage 1.

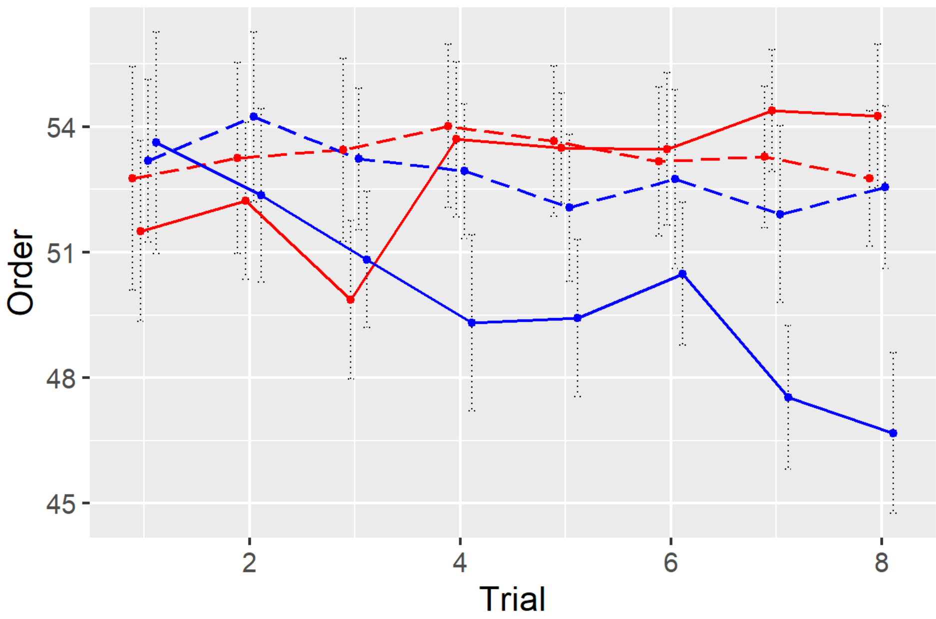
Figure 5 plots the dynamics of the first bids and asks in each of the treatments. Although the first asks present similar dynamics in the two treatments, the first bids exhibit distinct patterns across these same two treatments. As the trial proceeds, the bids tend to become lower in Tree, whereas they tend to become higher in Cycle.

We perform the following linear regression analysis to test this observation. We regress the first bids and asks on the same four explanatory variables as our earlier regression for prices (i.e., *Cycle*, *Latter*, *Cycle* $\times$ *Latter*, and a constant). Now the regression model is a fixed-effect model in which the subject-level individual heterogeneity is controlled for by individual fixed effects. In addition, we employ cluster-robust (subject-level) standard errors for the hypothesis tests. As before, we also report the result of a regression including only two regressors, *Cycle* and a constant.

Table 5 presents the regression results for the first bids and asks in Stage 1.

[11] Recall that players are randomly rematched into groups of three at the beginning of each trial, but while maintaining their roles.

[12] One concern is that first bids and asks also reflect the individual heterogeneity of player, such as negotiation style. For this reason, we control for individual differences in the following regression analysis.



Red: Cycle, Blue: Tree.
Solid: bids, Long-dash: asks

Figure 5: Dynamics of the First Bids and Asks

The first column in Table 5 indicates that the first bids in Tree is larger than in Cycle by 2.302 ($p - value = 0.024$). The second column displays the regression result to address the presence of learning effects. The value of the coefficient of *Latter* is -3.289, which is significantly different from zero ($p - value < 0.01$), indicating that the first bids in Tree have a strong downward trend as observed in Figure 5. For Cycle, the value of the coefficient of the cross term $Cycle \times Latter$ is 4.227, which is significantly different from zero ($p - value < 0.01$). This indicates the presence of a treatment-specific learning effect. The sum of the coefficients of $Cycle \times Latter$ and *Latter*, which captures the magnitude of the learning effect in Cycle, is 0.938, suggesting the possibility of an upward trend in first bids in Cycle. Although

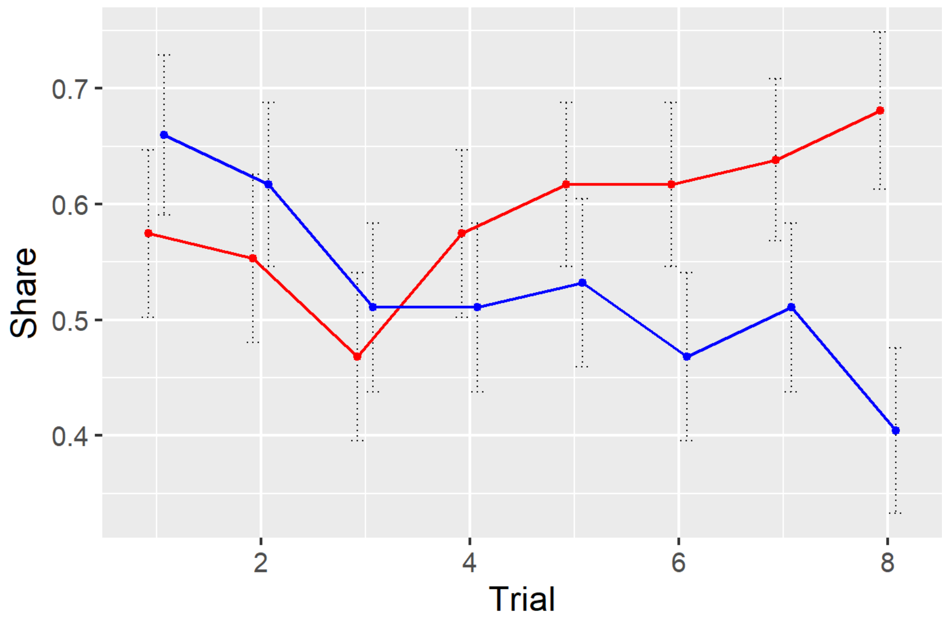
Table 5: First Bids and Asks in Stage 1

	Dependent Variable			
	First Bids		First Asks	
	Model 1	Model 2	Model 1	Model 2
Cycle	2.302^{**}	0.188	0.436	-0.027
	(1.006)	(1.545)	(0.916)	(1.541)
Cycle × *Latter*	-	4.227^{***}	-	0.926
		(1.525)		(1.878)
Latter	-	-3.289^{***}	-	-1.080
		(1.083)		(1.499)
Const.	50.297^{***}	51.942^{***}	52.859^{***}	53.399^{***}
	(0.503)	(0.826)	(0.458)	(0.951)
Observations	752	752	752	752
R^2	0.0121	0.0209	0.0003	0.0011

*p<0.1; **p<0.05; ***p<0.01. Cluster-robust standard errors in parentheses.

this value is not statistically significant using pooled data of the two treatments (F-test, $p - value = 0.3319$), using the data only in Cycle, we confirm a statistically significant positive upward trend in Cycle, as shown in Figure 5 ($p - value = 0.038$, Table V.1 in OSM V). The first bids exhibit treatment-specific learning in opposite directions across the two treatments.

Unlike the first bids, we do not observe any treatment-specific learning in the first asks. The third column in Table 5 indicates that the overall level of the first asks does not differ significantly across the two treatments ($p - value = 0.636$). Moreover, in the fourth column, neither the coefficient of the cross term $Cycle \times Latter$ nor the term $Cycle$ is significant ($p-value =$ 0.624 and 0.986, respectively). These results jointly imply that the behavior of sellers does not differ across the two treatments.



Red: Cycle. Blue: Tree

Figure 6: Share of Successful Negotiations in the First Trials

Result 5: In Stage 1, buyers become more willing to buy as trials proceed in Cycle. By contrast, buyers become less willing in Tree. Sellers do not exhibit any treatment-specific learning.

As we observe distinct treatment-specific learning effects in the first bids but not the first asks, we expect that the likelihood of success in the first trials evolves differently across the two treatments as the trials progress. That is, the first negotiations should more likely succeed in Cycle than in Tree in later trials. To see this, we plot the dynamics of the likelihood of the success of negotiations in the first trials in Figure 6. As expected, this likelihood displays an upward (downward) trend in Cycle (Tree).

To examine the difference, we perform the following linear regression analysis. We regress a dummy variable reflecting the success of the first trials

Table 6: Likelihood of Success in the First Negotiations

	Dependent Variable	
	Success	
	Model 1	Model 2
Cycle	0.064*	−0.032
	(0.036)	(0.051)
Cycle × *Latter*	-	0.191***
		(0.072)
Latter	-	−0.096
		(0.051)
Const.	0.527***	0.574***
	(0.026)	(0.036)
Observations	752	752
R^2	0.0041	0.0134

*p<0.1; **p<0.05; ***p<0.01.

on the same four explanatory variables to the earlier regression analysis of prices (i.e., *Cycle*, *Latter*, *Cycle* × *Latter*, and a constant). Table 6 presents the regression results. As shown in the first column, we do not identify any clear difference in the likelihood of success in the first negotiations across the treatments. However, in the second column, we observe a strong treatment-specific learning effect as the coefficient of the cross term *Cycle* × *Latter* is 0.191 and is significant ($p - value < 0.01$). According to these results, the first negotiations in Cycle are more likely to be successful in later trials by approximately 19% than in Tree.

The abovementioned findings consistently suggest that buyers become more willing to buy in the latter trials in Stage 1 in Cycle. It then becomes difficult that prices in Stage 1 in Cycle will be lower as learning progresses.

Thus, and once again, we conclude that learning does not help to achieve equilibrium in Stage 1 in Cycle, at least in the eight trials in our experiments. Instead, it tends to widen the gap from the equilibria.

One straightforward explanation for the results in Cycle is that, first, buyers could earn large profits in Stage 2 because, unlike the theoretical prediction, the prices are high in Stage 2. Expecting positive profits in Stage 2, buyers then compete to purchase the good in Stage 1. As the expected returns in Stage 2 are gradually learned, a learning effect then appears in Stage 1.

A puzzle is why the sellers in Cycle do not exploit their advantage in competition and become more eager to earn profits in Stage 1. As discussed, the first asks do not differ across the two treatments, nor do they seem to respond to the upward trend in first bids. It might be the case in our experiments that those who are competing only become urged, though the reason behind it is unclear.

5.4 First Bids and Asks in Stage 2

We find that the buyers in Stage 1 in Cycle become more willing to buy the good. Naturally, a next question would be whether the sellers competing in Stage 2 learn to be more aggressive. More specifically, we hypothesize that the first asks proposed by the sellers in Stage 2 in Cycle are lower than those in Tree. Here, the "first ask" in Stage 2 is defined as the ask proposed in the round immediately following establishment of the Stage 1 transaction.

To test our hypothesis, we perform linear regression analysis of the first

Table 7: First Bids and Asks in Stage 2

	Dependent Variable			
	First Bids		First Asks	
	Model 1	Model 2	Model 1	Model 2
Cycle	0.018	-1.166	-3.969^{***}	-4.422^{***}
	(1.060)	(1.200)	(1.211)	(1.635)
Cycle × *Latter*	-	2.391	-	0.915
		(1.462)		(1.836)
Latter	-	-1.858^{*}	-	-0.441
		(0.954)		(1.505)
Const.	48.066^{***}	48.989^{***}	50.144^{***}	50.362^{***}
	(0.526)	(0.794)	(0.601)	(1.023)
Observations	695	695	695	695
R^2	0.0000	0.0043	0.0193	0.0190

*p<0.1; **p<0.05; ***p<0.01. Cluster-robust standard errors in parentheses.

asks and the first bids in Stage 2. The regression models are identical to those used for Stage 1 (i.e., identical variable definition, fixed-effect models for controlling subject-level heterogeneity, and cluster-robust standard errors). The results are presented in Table 7. Consistent with the abovementioned hypothesis, the first asks in Cycle are significantly lower than those in Tree. The results in the third column show that the value of the coefficient of *Cycle* is -3.969, which is significant ($p - value < 0.01$).[13] This result echoes our earlier findings for Stage 2 prices that prices tend to be lower in Cycle, although the magnitude of this is not sufficient to satisfy the theoretical prediction.

[13]The difference in the first asks in Stage 2 could also result from differences in asking behavior between originators and resellers. However, OSM VI shows that this is not the case.

However, different from the case of the first bids in Stage 1, we do not reveal learning effects for the first asks in Stage 2. The fourth column of Table 7 shows that the coefficient of the term *Latter* is not significantly different from zero ($p - value = 0.770$). The coefficient of the cross term $Cycle \times Latter$ is also not significant ($p - value = 0.619$), nor is the sum of the coefficients of $Cycle \times Latter$ and *Latter* (F-test, $p - value = 0.630$). These results jointly suggest that there is no learning effect in either treatment in the first asks in Stage 2. One reason for the difference in this to the first bids in Stage 1 is that optimal trading in Stage 1 might require more cognitive ability. To make an appropriate offer in Stage 1, players need to foresee the expected profit they could obtain in Stage 2, unlike the transactions in Stage 2. It is then possible that the buyers in Cycle learn the prices determined in Stage 2 as the trials progress and gradually adapt their bids in Stage 1.

In addition, similar to the first asks in Stage 1, we do not observe any significant difference in the first bids across the two treatments in Stage 2. As shown in the first column of Table 7, the coefficient for *Cycle* is not significant ($p - value = 0.987$). Moreover, in the second column, the coefficient for the cross term $Cycle \times Latter$ as well as the coefficient for the term *Cycle* are also not significant ($p - value = 0.105$ and 0.333, respectively). These results jointly suggest that the behavior of buyers in Stage 2 is similar across the two treatments. This aligns with our earlier speculation that those who are competing only feel urged, though the reason behind it is still puzzling.

Result 6: In Stage 2, sellers are more willing to sell in Cycle than in Tree, though the magnitude of this is not sufficient to satisfy the theoretical prediction. Moreover, there is no evidence of learning or buyers behaving differently across the two treatments.

5.5 Forward-looking Behavior Given the Observed Stage 2 Prices

We have documented a gap between the theoretical prediction and the experiment results in Cycle. Recall that, in theory, the Stage 1 price is low in Cycle because buyers expect the competition between sellers to push down the Stage 2 price, and thus the expected profit from reselling the good should also fall. Therefore, if the price is high in Stage 1, the buyer prefers to let the current negotiation pass, wishing to be the buyer in Stage 2.

However, the high Stage 1 price observed in the experiment could be reasonable if subjects expect a high price in Stage 2. The larger the expected reselling profit in Stage 2, the more willing buyers in Stage 1 are to buy the good, which in turns raises the Stage 1 price. Here, we address the possibility that the observed prices in Stage 1 are explained by reasonable profit-seeking behavior of subjects foreseeing the prevailing high prices in Stage 2.

To assess the reasonable level of the Stage 1 price given the prevailing Stage 2 price, as denoted by the "pseudo equilibrium Stage 1 price," we plug the mean observed Stage 2 prices into Eq. (6). The derived pseudo equilibrium Stage 1 price is 48.16. The mean Stage 1 price (53.86) is then higher than its pseudo equilibrium level by 5.73, which is within the extent that can be explained by the risk-averse behavior of our subjects, as discussed in Appendix A. Thus, the observed prices in Stage 1 do not contradict our subjects pursuing a larger benefit by foreseeing future reselling prices in Stage 2.

6 Conclusion

This study experimentally examines the trading of information goods in networks. Information goods are copyable; hence, a buyer can become a resale competitor to existing sellers once the good is purchased and if resales channels are available in the network. We examine whether competition through reselling lowers the prices of the good in line with theory.

Our experimental treatment is the network structure that permits competition through reselling. In one treatment, Cycle, the network includes a cycle path, which secures a sales channel for the reseller. Thus, price competition could lower prices between the originator and the reseller in the network. According to theory, the lowering effect in prices even moves upstream to the first transaction where no resale competitor yet exists, because the market participants foresee competition through reselling in their future transactions. In the other treatment, Tree, there is no cycle path in the network, and thus resale of the good is not possible. The originator can then enjoy monopoly power and post higher prices.

We find that the prices observed in Cycle are inconsistent with theory compared with those observed in Tree. Specifically, although competition between the originator and the reseller lowers the observed prices in the final transaction more in Cycle than in Tree, the extent of this is very small compared with the theoretical prediction. In addition, contrary to the theoretical prediction, the prices in the first transaction tend to be higher in Cycle than in Tree.

Furthermore, learning does not resolve the discrepancy between the theory and the data in Cycle as the Stage 1 prices carry signs of further price increases according to the bidding behavior of the buyers. On the contrary, in Tree, the bidding behavior suggests signs of further decreases in prices toward the level implied by the theory.

As we discussed in Section 5.5, the observed prices in Stage 1 of Cycle, although inconsistent with their theoretical prediction, are consistent with participants rationally responding to the prevailing high prices in Stage 2. Thus, there is the possibility that Stage 1 prices could adjust toward their theoretical level once the Stage 2 prices fall due to competition.

It is possible that the bargaining protocol we employed in our experiment, namely, the Nash demand game, serves to soften the competitive pressure in Stage 2 in Cycle. Thus, an obvious direction for future research would be to consider an alternative trading mechanism, such as a continuous double auction. Another possibility is that the two players in our experiment are not sufficient for competition to be effective. For example, in Dufwenberg and Gneezy (2000), when the number of players was three or more, participants quickly learned to compete more aggressively in a Bertrand competition experiment. Thus, other obvious and fruitful future research would be to consider networks involving a larger number of players.

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A Case for Risk-averse Players

As in Section 5.5, the observed Stage 1 price is higher than the pseudo equilibrium Stage 1 price by 5.73. Here we show that this difference can be explained by the risk aversion of players.

To address this, we modify Eq. (6) to consider risk-averse players maximizing their expected utilities over final payoffs.

$$\begin{aligned}
&\frac{1}{2}u(100 - p_1^C) + \frac{1}{2}u(100 - p_1^C + p_2^C) = \\
&\qquad \frac{1}{2}\delta\{\frac{1}{2}u(100 - p_1^C) + \frac{1}{2}u(100 - p_1^C + p_2^C)\} + \frac{1}{2}\delta u(100 - p_2^C) + \\
&(1-\alpha)[\frac{1}{2}u(p_1^C) + \frac{1}{2}u(p_1^C + p_2^C) + \frac{1}{2}u(100 - p_1^C) + \frac{1}{2}u(100 - p_1^C + p_2^C) - \\
&\delta\{\frac{1}{2}u(p_1^C) + \frac{1}{2}u(p_1^C + p_2^C)\} - \frac{1}{2}\delta\{\frac{1}{2}u(100 - p_1^C) + \frac{1}{2}u(100 - p_1^C + p_2^C)\} - \frac{1}{2}\delta u(100 - p_2^C)]
\end{aligned} \tag{A.1}$$

where $u(\cdot)$ is the utility function of the players.

Let us specify the utility function with a standard, constant relative risk aversion utility function with the coefficient of relative risk aversion γ (i.e., $u(x) = \frac{1}{1-\gamma}x^{1-\gamma}$). Substituting the values for the observed prices into p_1^C and p_2^C, we obtain $\gamma = 5.11$. This value of γ is within the scope of reasonable degrees of risk aversion in existing studies (for example, Abdulkadri and Langemeier, 2000).

Online Supplementary Materials

I Sessions and Treatment Order

Table I.1: Sessions

	Subject	First Treatment
October 1, 2020 (morning)	21	Cycle
October 1, 2020 (afternoon)	24	Tree
October 2, 2020 (morning)	24	Cycle
October 2, 2020 (afternoon)	18	Tree
October 14, 2020 (morning)	24	Tree
October 15, 2020 (morning)	30	Cycle

II Order Effect

As the treatments are reverse ordered among our subjects by roughly dividing them in half, the order effects should offset each other at the aggregate level. However, fully documenting the order effects in our data would be meaningful. In addition, there may be some concern that the remaining unevenness of the numbers of subjects between the reverse-ordered sessions (66 subjects starting from Tree, and 75 from Cycle) could be a source of potential bias, even though the difference in the number of subjects is small.

To address this, we regress the prices on four explanatory variables, $TreeFirst$, $Cycle$, $Cycle \times TreeFirst$, and a constant. $TreeFirst$ is a dummy variable that takes a value of one if the subject is assigned to the session that starts with Tree, otherwise zero. This variable captures the existence of an overall order effect. $Cycle$ is a dummy variable that takes a value of one if

Table II.1: Order Effect in Prices

	Dependent Variable			
	Price			
	Stage 1		Stage 2	
	Model 1	Model 2	Model 1	Model 2
$TreeFirst$	-3.136^{***}	-2.339^{***}	-2.736^{***}	-2.569^{**}
	(0.681)	(0.957)	(0.737)	(1.043)
$TreeFirst \times Cycle$	-	-1.617	-	-0.311
		(1.357)		(1.469)
$Cycle$	-	2.276^{**}	-	-1.766^{*}
		(0.925)		(0.988)
$Const.$	54.551^{***}	53.426^{***}	49.532^{***}	50.418^{***}
	(0.464)	(0.651)	(0.496)	(0.700)
Observations	695	695	623	623
R^2	0.0297	0.0387	0.0217	0.0324

*p<0.1; **p<0.05; ***p<0.01.

the trial belongs to Cycle, otherwise zero. $TreeFirst \times Cycle$ is the cross term of $TreeFirst$ and $Cycle$, whose significance would indicate the presence of distinct order effects across the two treatments. We also report the results of a regression including only two regressors, $TreeFirst$ and a constant.

The results of the regressions are presented in Table II.1, with the results for Stage 1 prices in the first and second columns and those for Stage 2 in the third and fourth columns. These results suggest some order effects in the price determinations as the coefficients for $TreatFirst$ are uniformly significantly different from zero to the negative side in both Stages 1 and 2 for both Models 1 and 2 ($p - value < 0.05$ for all). These results imply that the prices tend to be lower if the subjects receive Tree first.

However, we do not confirm a treatment-specific order effect as neither of the coefficients for the cross term $TreeFirst \times Cycle$ in Stage 1 (second column) or in Stage 2 (the fourth column) statistically significantly differ from zero ($p - value = 0.234$ and 0.833 respectively).

Accordingly, the order effect observed in the data only changes the overall price levels across the treatments, but not the level in a specific treatment. Thus, the bias should not appear when we compare behavior between the two treatments, even if there is some discrepancy in the number of subjects between the reverse-ordered sessions.

III Likelihood of Successful Trials

This section of OSM documents the statistical comparison of the likelihood of successful trials across the two treatments. Here we examine the treatment effects and the associated learning effects.

To do this, we perform the following linear regression analysis. We regress the dummy variable for the success of the trial on the four explanatory variables, $Cycle$, $Latter$, $Cycle \times Latter$, and a constant. $Cycle$ is a dummy variable that takes a value of one if the trial belongs to Cycle, otherwise zero. $Latter$ is a dummy variable that takes a value of one if the trial lies in the latter half of each treatment (i.e., 5th to 8th trials), otherwise zero. This captures the overall learning effects across the treatments (unless a negatively significant treatment-specific learning effect exists in Cycle). $Cycle \times Latter$ is the cross term of $Cycle$ and $Latter$, and this captures any additional impact on the learning effect specifically appearing in Cycle. The statistical

Table III.1: Likelihood of Successful Trials

	Dependent Variable			
	Success			
	Whole transactions		Stage 1 transaction	
	Model 1	Model 2	Model 1	Model 2
Cycle	0.013	-0.011	-0.013	-0.016
	(0.028)	(0.039)	(0.019)	(0.027)
Cycle × *Latter*	-	0.048	-	0.005
		(0.055)		(0.039)
Latter	-	-0.027	-	0.000
		(0.039)		(0.027)
Const.	0.822^{***}	0.835^{***}	0.931^{***}	0.931^{***}
	(0.019)	(0.028)	(0.014)	(0.019)
Observations	752	752	752	752
R^2	0.0003	0.0013	0.0006	0.0007

*p<0.1; **p<0.05; ***p<0.01.

significance of the variable indicates that the learning effects differ across the treatments (i.e., the existence of treatment-specific learning effects). The learning effect in Tree is captured by the coefficient of the term *Latter*, and that in Cycle by the sum of the coefficients of the terms *Latter* and *Cycle* × *Latter*. We also report the result of a regression in which only two regressors are included, *Cycle* and a constant, to gauge the treatment effect over all trials.

The regression results are presented in Table III.1. The results for the whole transaction are presented in the first and second columns. The coefficient of *Cycle* in Model 1 in the first column does not statistically significantly differ from zero ($p - value = 0.629$), indicating that the likelihood of success does not differ across the two treatments on average over all trials. Moreover, the coefficient of $Cycle \times Latter$ in Model 2 in the second column does not differ statistically significantly from zero ($p - value = 0.385$), indicating that a treatment-specific learning effect does not exist. Indeed, the results of the insignificant coefficient of $Latter$ ($p - value = 0.495$) and the insignificant sum of the coefficients of $Latter$ and $Cycle \times Latter$ (F-test, $p - value = 0.585$) imply that there exists no learning effect in both treatments.

The results for the first transaction basis are also similar as presented in the third and fourth columns. The coefficient of $Cycle$ in Model 1 in the third column does not statistically significantly differ from zero ($p - value = 0.492$). The coefficient of $Cycle \times Latter$ in Model 2 in the fourth column does not differ statistically significantly from zero ($p - value = 0.891$). The coefficient for $Latter$ is also not significant ($p - value = 1.000$), nor is the sum of the coefficients $Latter$ and $Cycle \times Latter$ (F-test, $p - value = 0.846$).

These results suggest that the likelihood of a successful trial does not differ across the two treatments. In addition, we do not identify any treatment-specific learning effect, or any learning effects themselves in both treatments. Thus, we do not need to be unduly concerned about uneven sample dropouts across the two treatments resulting from sudden ceases in ongoing negotiations.

IV Number of Negotiations

As discussed above, we do not find any significant difference in the likelihood of successful trials across the two treatments, which eliminates any concern about uneven sample dropouts across the two treatments. However, it might be useful to also analyze the numbers of negotiations. Like the case of the likelihood of successful trials, we examine the treatment effects and the associated learning effects.

We perform a linear regression analysis similar to the analysis for the likelihood of successful trials in OSM III, where we regress the number of negotiations in the trial on the four explanatory variables, $Cycle$, $Latter$, $Cycle \times Latter$, and a constant. We also report the results of a regression including only two regressors, $Cycle$ and a constant.

Table IV.1 displays the regression results. As shown in the first and third columns, the coefficients for $Cycle$ differ statistically significantly from zero on the negative side, indicating that the overall number of negotiations is smaller in Cycle ($p - value < 0.01$ for both), as first suggested in Table 2 in Section 4.

For the learning effects, the results for the whole transaction basis displayed in the second column suggest a learning effect in Tree as the coefficient for $Latter$ is significantly different from zero (0.414, $p - value = 0.048 < 0.05$). However, the existence of a learning effect in Cycle is less clear as the sum of the coefficients for $Latter$ and $Cycle \times Latter$ is near zero (F-test, $p - value = 0.773$), which implies less possibility that a learning effect exists in Cycle. Nonetheless, the coefficient for $Cycle \times Latter$ is not significant

Table IV.1: Number of Negotiations

	Dependent Variable			
	Number of Negotiations			
	Whole transactions		First transaction	
	Model 1	Model 2	Model 1	Model 2
Cycle	-0.487^{***}	-0.253	-0.255^{***}	-0.094
	(0.147)	(0.207)	(0.084)	(0.118)
Cycle × *Latter*	-	-0.473	-	-0.321^{*}
		(0.294)		(0.168)
Latter	-	0.414^{**}	-	0.155
		(0.208)		(0.119)
Const.	3.579^{***}	3.376^{***}	1.783^{***}	1.707^{***}
	(0.104)	(0.146)	(0.060)	(0.083)
Observations	623	623	623	623
R^2	0.0173	0.0256	0.0146	0.0204

*p<0.1; **p<0.05; ***p<0.01.
Limited to trials with whole transactions among the three players.

($p - value$ = 0.108), although the value of the point estimate is negative and large (-0.473), suggesting that while a treatment-specific learning effect could exist, the evidence for this is not sufficiently strong. For the first transaction basis, not only do we not identify a significant treatment-specific learning effect, but we also do not find any significant learning effect in the treatments. This is because while in the fourth column the coefficient for *Cycle* × *Latter* has a large negative value (-0.321), it is only marginally significant ($p - value = 0.056$). Thus, while a treatment-specific learning effect could exist, there is insufficient evidence to support it. Indeed, the coefficient for *Latter* is not significant ($p - value = 0.194$), along with the sum of the coefficients for *Latter* and *Cycle* × *Latter* ($p - value = 0.159$), suggesting that the presence of learning effects themselves is unclear.

Overall, some differences in learning effects across the two treatments might exist as the large values in the coefficients of the term $Cycle \times Latter$ suggest. However, the evidence for this is not statistically meaningful.

Moreover, we also examine the number of negotiations across the two stages (first vs. second), which could be different in Cycle in which the negotiation structure changes drastically across the two stages. We regress the number of negotiations in each stage of each trial on the four explanatory variables, $SecondST$, $Latter$, $SecondST \times Latter$, and a constant. $SecondST$ is a dummy variable that takes a value of one if the corresponding negotiations are attempted in Stage 2. Thus, the cross term of $SecondST$ and $Latter$ captures a stage-specific learning effect. We also report the result of a regression including only two regressors, $SecondST$ and a constant.

The regression results are presented in Table IV.2. It is a straightforward result that none of the regressors associated with the term $SecondST$ are significantly different in Tree (the first and second columns). However, this also holds even in Cycle, in that the coefficient of $SecondST$ in the third column is not significant ($p - value = 0.681$), or are the coefficients for the cross term $SecondST \times Latter$ ($p - value = 0.109$) and $SecondST$ ($p - value = 0.394$). These results suggest that the numbers of negotiations do not change significantly across the stages, despite the considerable difference in negotiation structure in Cycle.

Table IV.2: Comparison of the Number of Negotiations across Stages

	Dependent Variable			
	Number of Negotiations			
	Tree		Cycle	
	Model 1	Model 2	Model 1	Model 2
SecondST	0.129	−0.038	0.035	−0.103
	(0.104)	(0.145)	(1.529)	(0.121)
SecondST × *Latter*	-	0.104	-	0.273
		(0.207)		(0.170)
Latter	-	0.155	-	−0.166
		(0.147)		(0.120)
Const.	1.783***	1.707***	1.529***	1.613***
	(0.073)	(0.103)	(0.060)	(0.086)
Observations	618	618	628	628
R^2	0.0000	0.0069	0.0003	0.0046

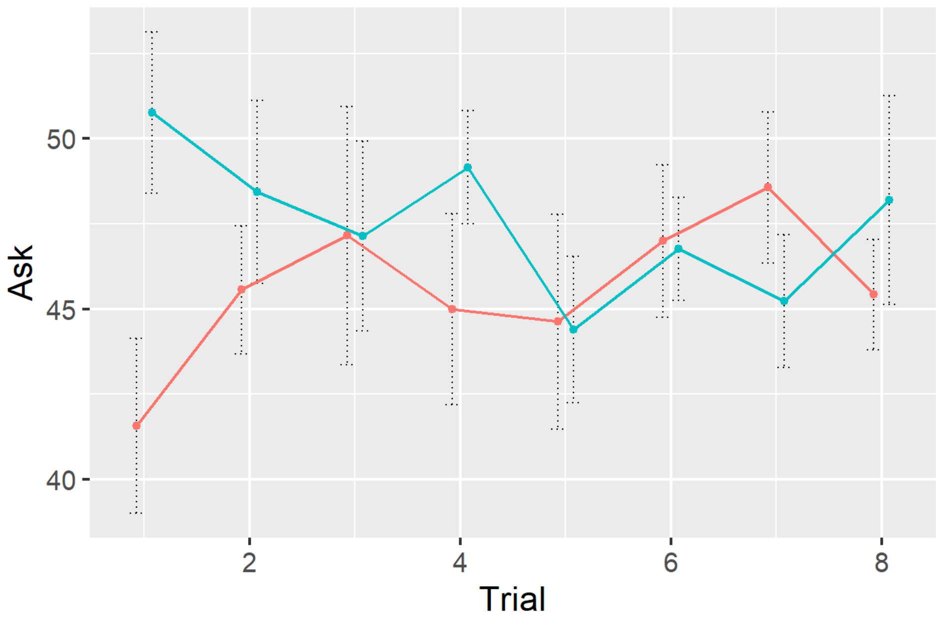
*p<0.1; **p<0.05; ***p<0.01.
Limited to trials with whole transactions among the three players.

V Supplemental Regression Results for the First Bids in Stage 1

Table V.1: Supplemental Regression Results for the First Bids in Stage 1

	Dependent Variable	
	First Bid	
	Tree	Cycle
Latter	-3.639^{***}	1.636^{**}
	(1.074)	(0.775)
Const.	51.851^{***}	52.047^{***}
	(0.537)	(0.388)
Observations	376	376
R^2	0.0124	0.0084

*p<0.1; **p<0.05; ***p<0.01.
Fixed-effect models for controlling subject-level individual heterogeneity.
Cluster-robust standard errors in parentheses.



Red: Originator, Green: Reseller (First Buyer)

Figure VI.1: First Asks in the Second Stages

VI First Asks in Stage 2

In Section 5.4, we observe that the first asks in Stage 2 differ significantly across the two experimental treatments. We could then consider the possibility that this difference arises because of the distinct roles of the sellers initially assigned in the experiment, either as an originator or as a buyer. This is because in Tree, the originator is the only seller even in Stage 2, while the first buyer could become a reseller in Stage 2 in Cycle.

To assess any behavioral differences between the two types of sellers in the first asks in Stage 2, we plot the dynamics of the mean value of these differences across trials in Figure VI.1. As displayed, the asks of originators are smaller than those of resellers in the early trials; they then converge to an almost identical level.

However, we do not statistically confirm a significant difference between them even in the early trials. Table VI.1 presents regression results to address the difference of the Stage 2 first asks between the two sellers. In Model 1, shown in the first column, the coefficient for *Originator* is not significantly different from zero ($p - value = 0.343$), indicating that the overall mean does not differ between the two types of sellers. Even for the early trials, the coefficient for *Originator* in Model 2 in the second column, which captures the difference in the early trials in the regression model specification, is only marginally significant ($p - value = 0.062$).

Accordingly, while the first asks could differ in the early trials, any difference is not sufficient to be statistically significant. Moreover, this difference, if any, soon disappears as the trials proceed.

Table VI.1: First Asks in Stage 2

	Dependent Variable	
	First Ask	
	Model 1	Model 2
Originator	−1.858	−4.184*
	(0.195)	(2.218)
Originator × *Latter*	-	4.626**
		(1.916)
Latter	-	−2.723*
		(1.570)
Const.	47.494***	48.886***
	(1.039)	(1.307)
Observations	345	345
R^2	0.0071	0.0186

*p<0.1; **p<0.05; ***p<0.01.
Cluster-robust standard errors in parentheses.

VII English translation of the instructions and the quiz

Instruction Screen 1

Explanations on the Experiment

In this game, three players (Player 1, 2 and 3) are involved in transactions of copies of ideas generated by Player 1.

Player 1 generates ideas, but only Player 2 or 3 can apply these ideas to business and create value. The values that Player 2 and 3 can create by acquiring the copies of the ideas are 100 points.

Since Player 1 can create multiple copies of her idea, she can sell her idea to multiple players.

Also, due to the absence of the protection of intellectual property rights, any player can resell to other players the copies of ideas she acquired if there is a chance to do so.

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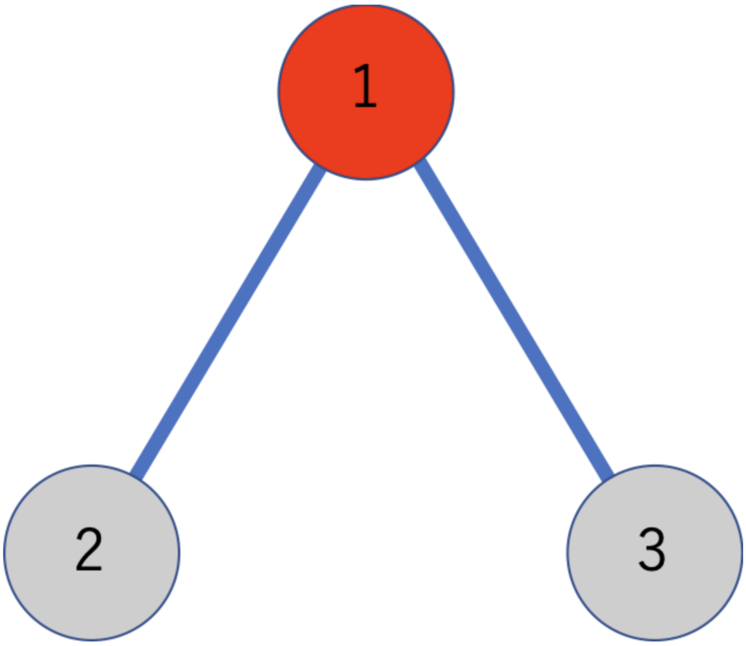
Instruction Screen 2

Opportunities to Make a Deal: Example 1



This illustration shows whether there is a chance to make a deal between each pair of players.

In this case, Player 1 can sell the idea to either Player 2 or 3.

However, Player 2 and 3 cannot make a deal for the idea between themselves.

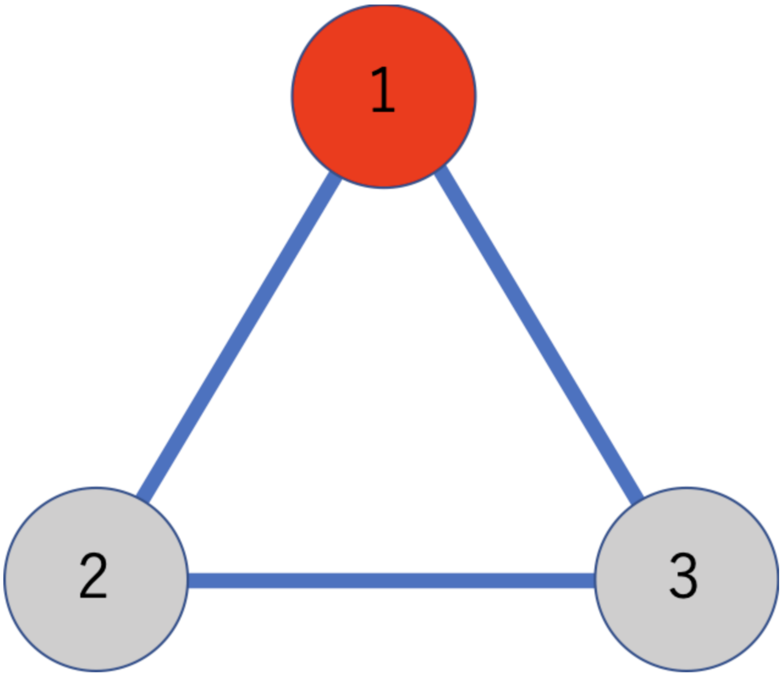
(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

次へ

Instruction Screen 3

Opportunities to Make a Deal: Example 2



In this case, Player 1 can sell the idea to either player 1 or player 2.

In addition, Player 2 and 3 can make a deal between themselves if either of them acquired the idea from player 1.

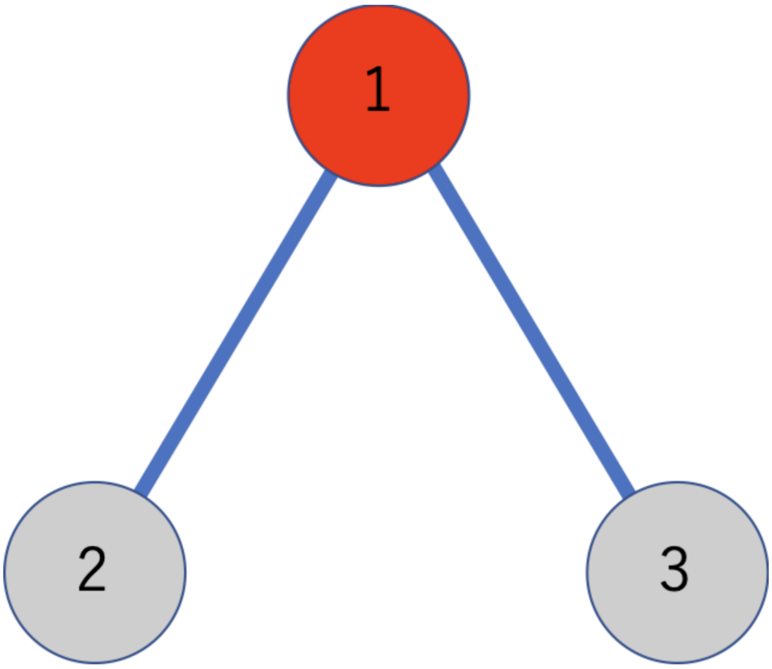
(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

次へ

Instruction Screen 4

Stage 1 of the game in Example 1



At the beginning of the game, only Player 1 has the idea.

In the diagram above, Player 1, who has the idea, is marked in red while Player 2 and 3, without the idea, are marked in grey.

Also, the illustration shows that Player 1 can make a deal with either Player 2 or 3.

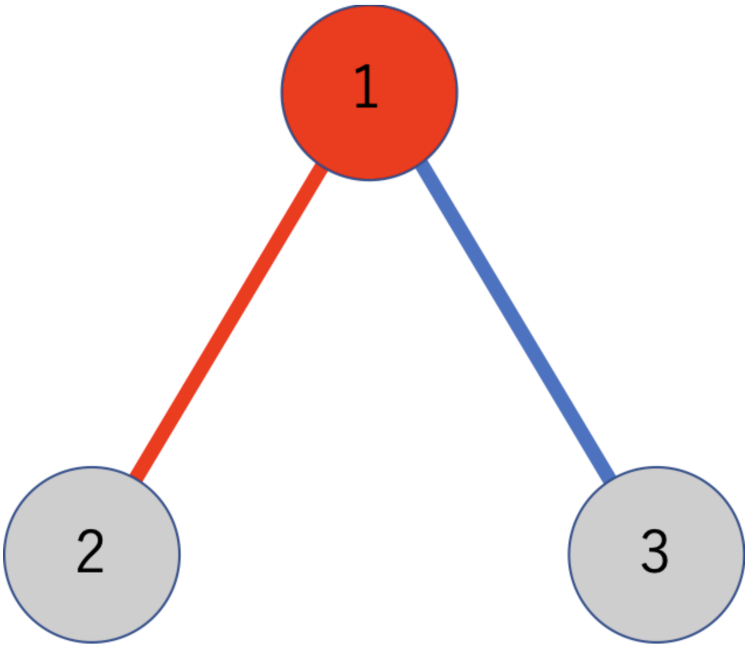
(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

次へ

Instruction Screen 5

Stage 2 of the game in Example 1



Once the game starts, one transaction link will be randomly selected connecting a player with the idea and a player without, and these players connected by the selected link will be able to make a deal between themselves.

The transaction link will be randomly selected with each possible link given an equal probability of being selected.

The selected transaction link will be highlighted in red. (In this case, the link between Player 1 and 2 was selected.)

The two players connected by the selected link will be able to negotiate the price of the idea as described on the next page.

(If you would like to see a previous explanation, please click the button below.)

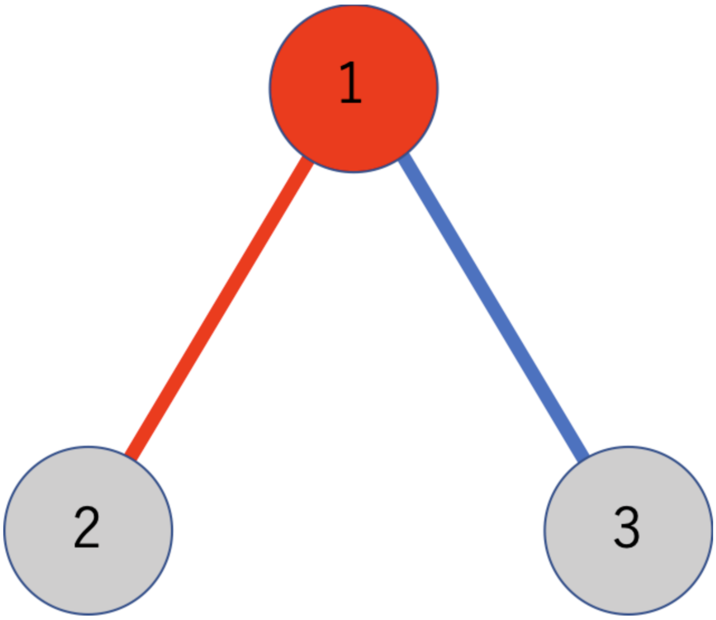
Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

次へ

Instruction Screen 6

Stage 3 of the game in Example 1：Methods of the Transaction



Player 1, who has the copy of the idea, will propose sales price A.

Player 2, who does not have the copy, will propose purchase price B below 100.

By obtaining the copy, Player 2 will be able to gain a value of 100.

If A is less than or equal to B, the idea will be sold at price P =（A + B）/ 2. This means that Player 1 will receive P from Player 2, and Player 2 will get 100-P from receiving the copy of the idea from Player 1.

If A is greater than B, the transaction will fail.

If the transaction fails, the game will end with probability 10%, and all players will gain 0. With probability 90%, they will return to the beginning of the game and one out of the two transaction links will be selected again.

(If you would like to see a previous explanation, please click the button below.)

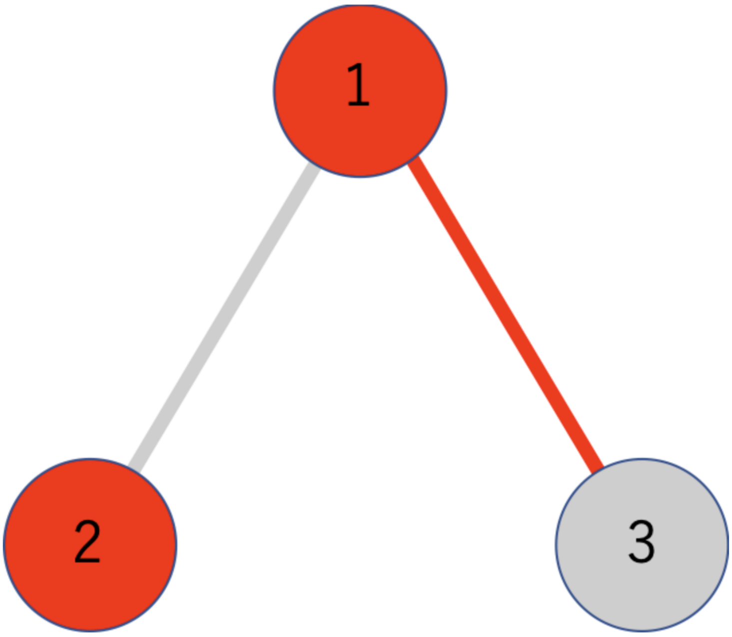
Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

次へ

Instruction Screen 7

Stage 4 of the game in Example 1: Results



The above diagram shows that the transaction between Player 1 and Player 2 has been successful.

Now, Player 1 and 2 have ideas.

Player 1 and Player 2 can no longer make transactions between themselves.

Player 1 and Player 3 can still make transactions between themselves.

In the next stage, the link between Player 1 and Player 3 will be selected and the two players will negotiate the price as previously explained.

(If you would like to see a previous explanation, please click the button below.)

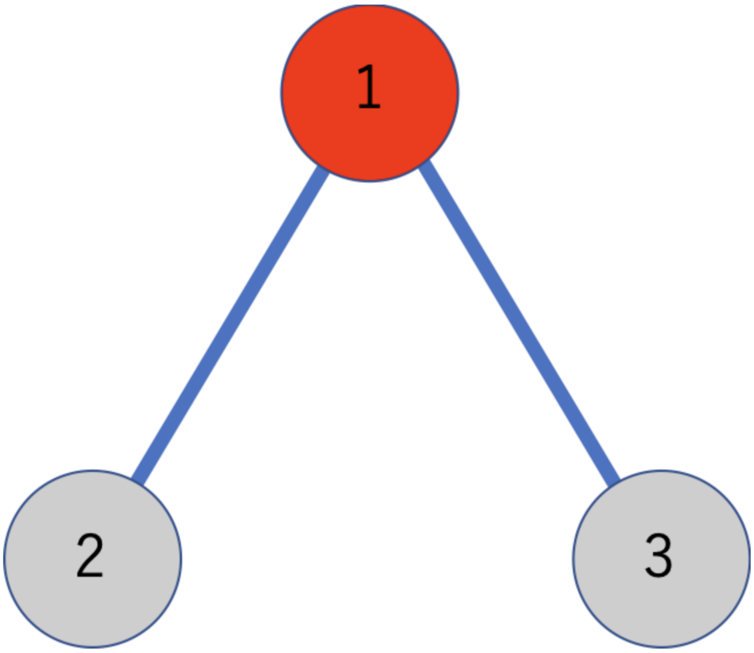
Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

次へ

Instruction Screen 8

Stage 5 of the game in Example 1: End or Continuation of the Game



As mentioned before, if the transaction is not successful, the game will end with probability 10%.

Also, the game will end when all players have the idea as a result of the transactions.

If a transaction is successful before the game ends, the players' points earned from the transaction will be kept.

If a transaction is successful and there is still a transaction link available or if the transaction fails and the game does not end, the game will continue and one of the remaining links will be selected, enabling transactions between the players.

(If you would like to see a previous explanation, please click the button below.)

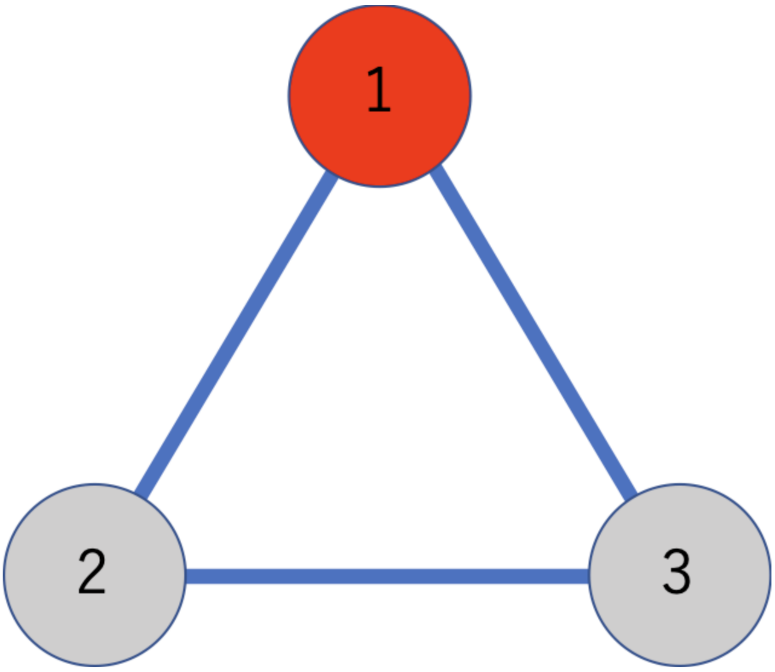
Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

次へ

Instruction Screen 9

Stage 1 of the game in Example 2



At the beginning of the game, only Player 1 has the idea.

In the diagram above, Player 1, who has the idea, is marked in red while Player 2 and 3, without the idea, are marked in grey.

Also, the diagram shows that Player 1 can make a deal with either Player 2 or 3.

Moreover, it is shown that if either Player 2 or Player 3 obtains the copy of the idea, they can make a transaction between themselves.

(If you would like to see a previous explanation, please click the button below.)

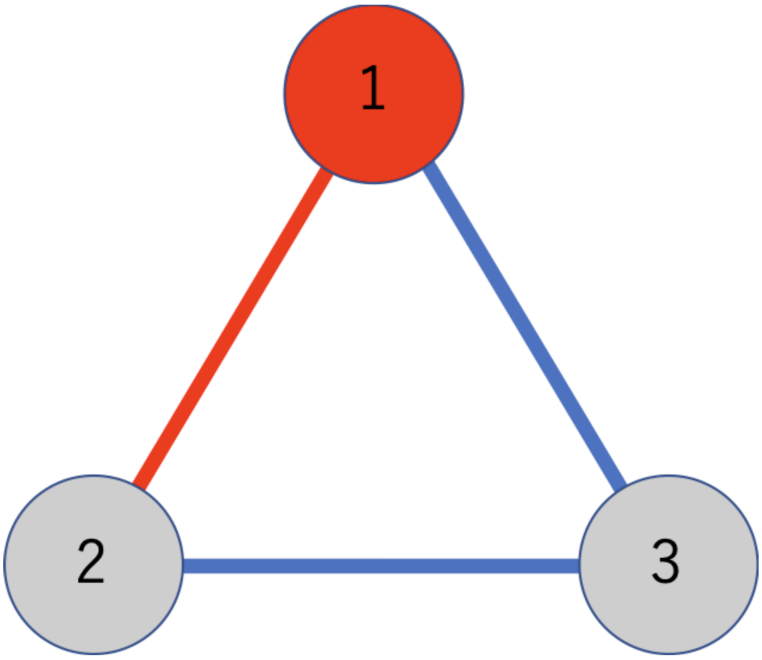
Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

次へ

Instruction Screen 10

Stage 2 of the game in Example 2



Once the game starts, one transaction link will be randomly selected connecting a player with the idea and a player without, and these players connected by the selected link will be able to make a deal between themselves.

The transaction link will be randomly selected with each possible link given an equal probability of being selected.

The selected transaction link will be highlighted in red. (In this case, the link between Player 1 and 2 was selected.)

The two players connected by the selected link will be able to negotiate the price of the idea as described on the next page.

(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

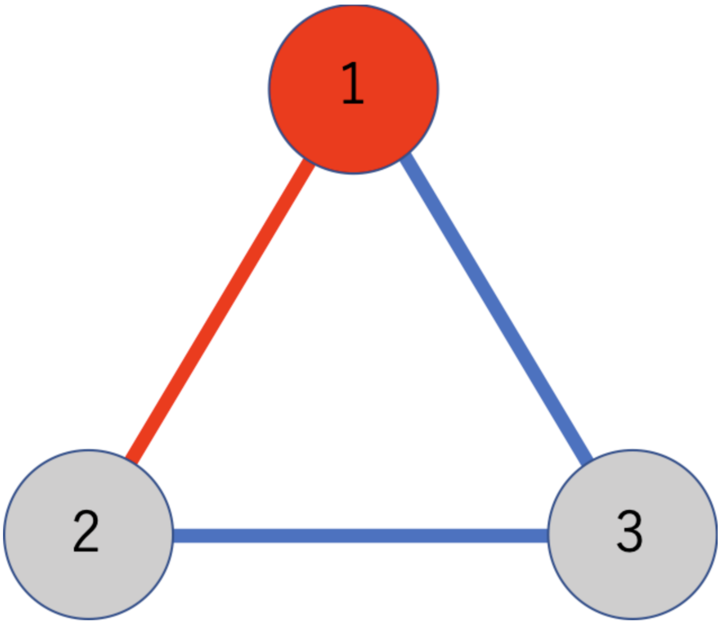
Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

次へ

Instruction Screen 11

Stage 3 of the game in Example 2：Methods of the Transaction



Player 1, who has the copy of the idea, will propose sales price A.

Player 2, who does not have the copy, will propose purchase price B below 100.

By obtaining a copy, Player 2 will be able to gain a value of 100.

If A is less than or equal to B, the idea will be sold at price P =（A + B）/ 2. This means that Player 1 will receive P from Player 2, and Player 2 will get 100-P from receiving the copy of the idea from Player 1.

If A is greater than B, the transaction will fail.

If the transaction fails, the game will end with probability 10%, and all players will gain 0. With probability 90%, they will return to the beginning of the game and one out of the two transaction links will be selected again.

(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

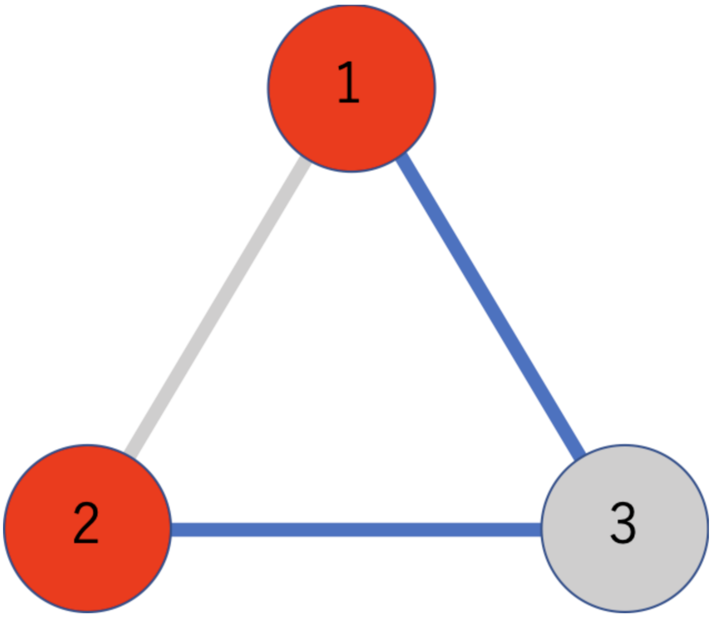
Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

次へ

Instruction Screen 12

Stage 4 of the game in Example 2：Results



The above diagram shows that the transaction between Player 1 and Player 2 has been successful.

Now, Player 1 and 2 have ideas.

Player 1 and 2 can no longer make transactions between themselves.

Transactions are still possible between Player 1 and 3、 and between Player 2 and 3.

In the next stage, either the link between Player 1 and 3 or that between Player 2 and 3 will be selected and two players will negotiate the price as previously explained.

(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

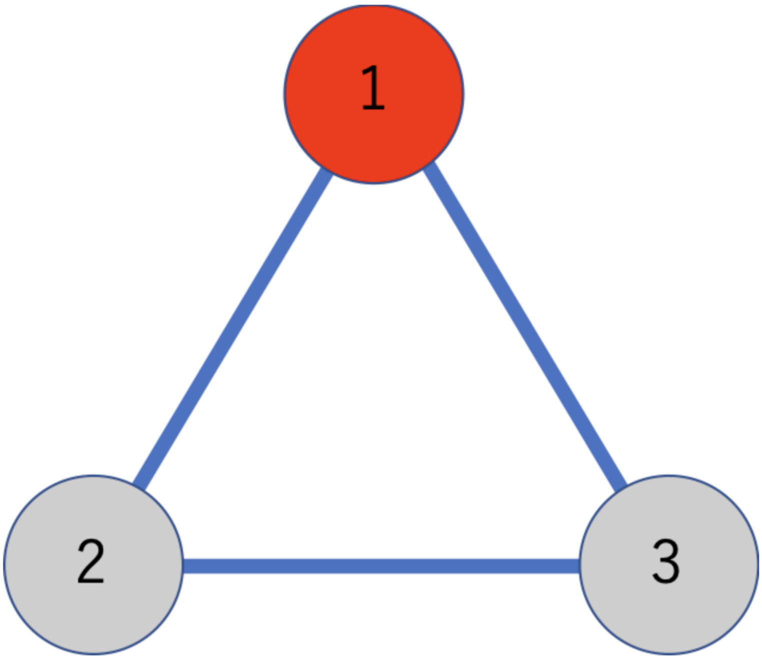
Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

次へ

Instruction Screen 13

Stage 5 of the game in Example 2: End or Continuation of the Game



As mentioned before, if the transaction is not successful, the game will end with probability 10%.

Also, the game will end when all players have the idea as a result of the transactions.

If transactions are successful before the game ends, the players' points earned from the transactions will be kept.

If a transaction is successful and there is still a transaction link available or if the transaction fails and the game does not end, the game will continue and one of the remaining transaction links will be selected, enabling transactions between the players.

(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

次へ

Instruction Screen 14

Determination of Points Earned

Once the game ends, the points earned will be recorded. Then, three players will be randomly selected and form another group for the next game.

The game repeats 16 times.

At the end of the experiment, one of 16 is randomly selected for payment. Points earned in this randomly selected game will be paid with the ratio of 1 point = 40 Yen, in addition to the participation payment.

You have been selected as Player 3. This player number will remain the same throughout the experiment.

(If you would like to see a previous explanation, please click the button below.)

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

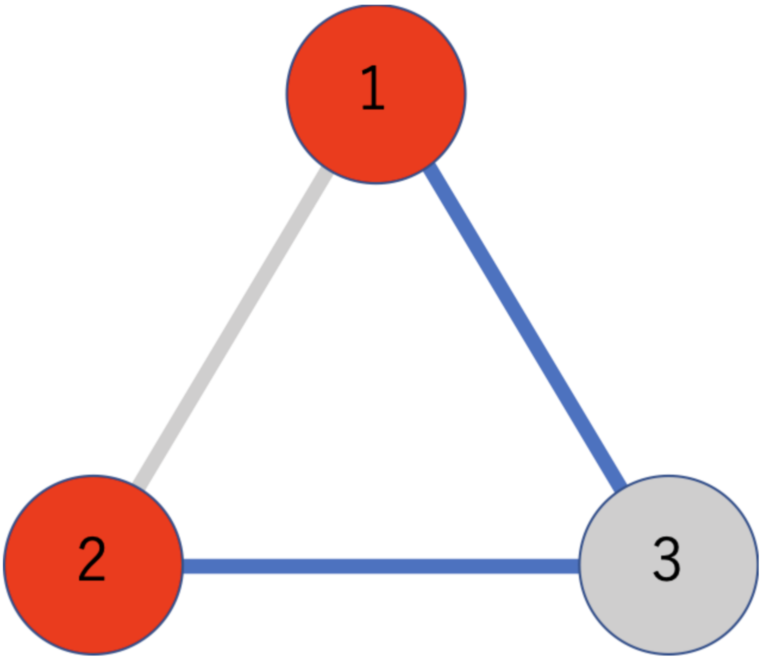
Explanations on the stages of the game in Example 2 (Click here)

次へ

Quiz 1

Check Question 1

With the explanations of the experiment, please answer the question below.



If the figure shows the current situation, which player(s) owns the idea?

Please select from the choices below.

Answer:

- ◯ Player 1
- ◯ Player 2
- ◯ Player 3
- ◯ Player 1 and Player 2
- ◯ Player 1 and Player 3
- ◯ Player 2 and Player 3
- ◯ Player 1 and Player 2 and Player 3

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

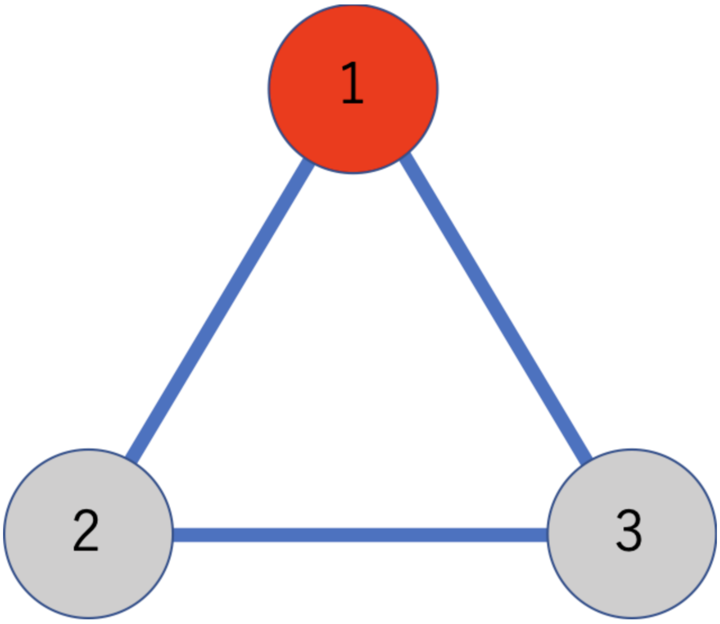
Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 2

Check Question 2

With the explanations of the experiment, please answer the question below.



As a result of the transaction in this stage, the player owns the idea as shown in the figure.

In this case, which player(s) can be chosen as the buyer of the idea in the next stage?

Please select from the choices below.

Answer:

- ◯ Player 1
- ◯ Player 2
- ◯ Player 3
- ◯ Player 1 or Player 2
- ◯ Player 1 or Player 3
- ◯ Player 2 or Player 3
- ◯ Player 1 or Player 2 or Player 3

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

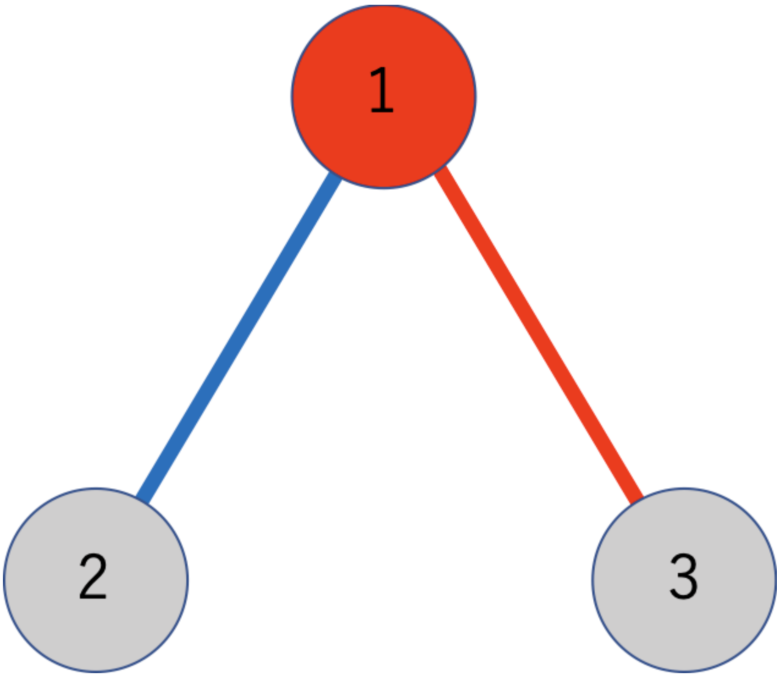
Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 3

Check Question 3

With the explanations of the experiment, please answer the question below.



In this stage, let us suppose that the transaction is taking place as shown in the figure

If this transaction is successful, which player(s) owns the idea in the next step?

Please select from the choices below./p>

Answer:

- Player 1
- Player 2
- Player 3
- Player 1 and Player 2
- Player 1 and Player 3
- Player 2 and Player 3
- Player 1 and Player 2 and Player 3

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

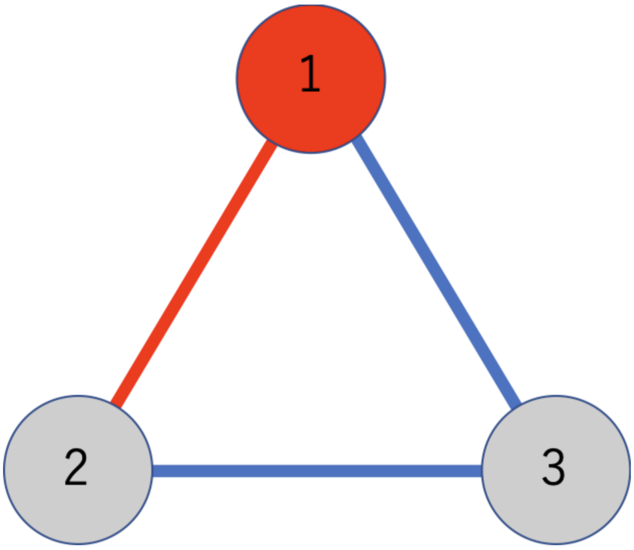
Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 4

Check Question 4

With the explanations of the experiment, please answer the question below.



As shown in the figure, let us suppose that the transaction is taking place between Player 1 and 2.

If Player 1 chooses 20 as the sales price and Player 2 chosses 40 as the purchase price, will this transaction be successful or not? Also, if the transaction is successful, what will be the final price at which the idea will be sold?

Please select from the choices below.

Answer:

- ◯ Transaction is successful at price 20
- ◯ Transaction is successful at price 30
- ◯ Transaction is successful at price 40
- ◯ Transaction is not successful

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 5

Check Question 5

With the explanations of the experiment, please answer the question below.

If the transaction fails in this stage, what is the probability that the game will continue on to the next stage?

Please select from the choices below.

Answer:

- ◯ Probability 90%
- ◯ Probability 80%
- ◯ Probability 70%
- ◯ Probability 60%

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 6

Check Question 6

With the explanations of the experiment, please answer the question below.

Let us suppose that you are Player 2 in Example 2. In the end, you were able to purchase the idea from player 1 at price 20 and gain 100 points.

Also, after acquiring the idea, you made copies of the idea and were able to sell one to Player 3 at price 30.

In this case, how many points were earned during the game?

Please select from the choices below.

Answer:

- ◯ 20
- ◯ 30
- ◯ 80
- ◯ 90
- ◯ 110
- ◯ 150

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)

Quiz 7

Check Question 7

16 th (/st/nd/rd) game was selected for the payment. The points earned in this game were 120.

In this case, how much is the payment for the points earned?

Please select from the choices below.

Answer:

- 2000 Yen
- 2400 Yen
- 3300 Yen
- 4800 Yen
- 6000 Yen
- 12000 Yen

次へ

Explanation on the outline of the experiment (Click here)

Explanations on the stages of the game in Example 1 (Click here)

Explanations on the stages of the game in Example 2 (Click here)

Explanation on the determination of points earned (Click here)