Friendship in Imperfectly Competitive Markets: Experiments with Substitutes and Complements*

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September 3, 2026

Abstract

How do social relationships affect imperfectly competitive markets? I conduct a controlled laboratory experiment using real-world friendships to answer this question. The paper reports two experiments. The first introduces friendships into Singh-and-Vives-style differentiated-product oligopolies under Bertrand and Cournot competition. The second varies whether friendships occur between sellers of substitutes or complements while keeping the market structure fixed. Social relationships among sellers of complements lower prices and boost efficiency, while those among sellers of substitutes do the reverse. This effect occurs because friends internalize externalities between them (directed altruism). Participants value their friend's profits at approximately 30% of their profits. Overall, results suggest that, in this context, social relationships act similarly to common ownership and mergers.

*Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy — EXC 2126/1-390838866.The research received IRB approval by the GfeW review board. The certificate can be viewed here https://gfew.de/ethik/i9TLp3ii.

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Adam Smith observed more than two centuries ago that friendly meetings among "people of the same trade" usually result in a conspiracy to raise prices.[1] Even in modern developed economies, social relationships are woven into markets and influence areas like the sale of real estate, the management of hotels, and the governance of large corporations. For example, some firms appoint friends of rival CEOs to their boards in order to circumvent restrictions on more explicit board interlocks.[2] This paper examines how social relationships influence market outcomes. Specifically, how do these relationships affect prices and efficiency? When are they beneficial or detrimental?

Although social relationships likely influence market outcomes, the exact nature of this influence remains unclear. Many industrial organization (IO) economists even view social ties as a significant barrier to competition that lies "beyond the reach of conventional analysis" (Scherer and Ross, 1984, p. 311). Two issues may explain this gap in our understanding. First, social relationships are endogenous and difficult to manipulate: They develop slowly, and natural experiments that change them are rare.[3] Second, social networks are high dimensional: There are many ways to link market participants. Each social relationship can have many aspects. For example, friendships can affect markets because friends are more altruistic towards each other or because they know more about each other.[4] To test the effect of social relationships, we need to reduce the complexity of social networks to a few parameters.

To address the first issue, I conduct a controlled laboratory experiment. In this experiment, I study friendships as a prototypical social relationship. To do so, I invite real-world friends to participate in laboratory markets and assign them different roles. This assignment results in a within-subject design, where the same individual makes choices in different social networks while everything else is constant.

To address the second issue, I focus on the relationship between social network links among sellers and if goods are substitutes or complements: Are the social relationships mainly between sellers of substitutes or sellers of complements? High prices have a negative externality on sellers of complements and a positive externality on sellers of substitutes. Consequently, if I want to help my friend (*directed altruism*), I will lower prices when she sells a complement and raise prices when she sells a substitute. The former benefits the buyer and likely raises efficiency, while the latter does the reverse.

I test this theory in two experiments.The first experiment uses a standard differentiated-products oligopoly environment (Singh and Vives, 1984), which facilitates comparisons

[1]See Smith (1776, p. 130).

[2]For an application to real estate, see Lindenthal et al. (2017); for hotel management, see Ingram and Roberts (2000); and for an example involving boards, see Westphal and Zhu (2019). For the broader argument, see Granovetter (1985).

[3]For exceptions, see Festinger et al. (1950); Sacerdote (2001); Goette et al. (2006).

[4]While there is extensive work on how social networks support contract enforcement (e.g. Karlan et al., 2009; Kranton, 1996), economics lacks empirical evidence on which model best explains how social networks affect efficiency within formal market institutions.

with the experimental oligopoly literature (e.g. Huck et al., 2004; Davis and Wilson, 2005; Anderson et al., 2010; Davis, 2011) Within subjects, participants play the same market game under both complement and substitute conditions, once with a friend and once with a stranger.

While the preceding design facilitates comparison with the existing literature, it varies two things at once: if products are substitutes or complements and if participants play with a friend or a stranger. The second experiment introduces a new four-player differentiated-products oligopoly game that holds the market fixed while varying only the social network structure. In this setting, players sell products that may be complements or substitutes to one another, allowing me to compare complement, substitute, and asymmetric friendship networks while keeping the market setting constant.

According to the preceding theory, friends may behave differently for two reasons: they want to help each other (*directed altruism*), and they might better anticipate each other's actions due to prior knowledge and experience (*familiarity*). I test the familiarity theory by analyzing whether friends have more accurate beliefs about each other's actions than strangers'.

This paper finds that the effect of friendship on market outcomes is driven by directed altruism. It does not find any evidence for the familiarity hypothesis. Friendship among sellers of complements lower prices and increase efficiency, while friendships among sellers of substitutes do the reverse.

I test whether a single underlying directed altruism parameter can explain the magnitudes of different treatment effects by estimating a structural model. In this model, participants maximize the sum of their own profits and their friend's profits, weighted with the directed altruism parameter.[5] A single homogeneous parameter can justify the increase in prices due to a friendship between sellers of substitutes and the decrease in prices due to a friendship between sellers of complements. In both experiments a representative participant will pay approximately 30 cents for her friend to receive one Euro.[6]

This paper shows that friendship, an important social relationship, can be modeled with a conventional tool that is shared between behavioral economics (Leider et al., 2009, 2010; Goeree et al., 2010; Ligon and Schechter, 2012) and industrial organization: Edgeworth's coefficient of effective sympathy (Edgeworth (1881) p.53, Vives (2020)). The coefficient of effective sympathy models the extent to which firms internalize other firms' profits. A recent application of this idea is the common ownership literature, where firms with common owners partially internalize each other's profits (Rubinstein and Yaari, 1983; Rotemberg, 1984; Azar et al., 2018; Backus et al., 2021; Ederer and Pellegrino, 2022). Mergers between two firms are mostly equivalent to full profit internalization.

[5]The model includes some additional parameters which are discussed in Subsection 3.3

[6]The estimate is approximately 28 cents in the two-player experiment and approximately 30 cents in the four-player experiment.

The differential effects of friendships among sellers of complements and substitutes are in line with the effect of the corresponding mergers, theorized by Cournot (1897). For friendships, Edgeworth's coefficient is the directed altruism parameter. In contrast to recent experiments that *induce* profit weights to model common ownership or cross-ownership (Hariskos et al., 2022; Frey et al., 2024; Yang and Potters, 2025), this paper uses real-world friendships and shows that they generate a similar form of profit internalization. This paper indicates that friendships replicate a particularly salient feature of (partial) mergers. Like (partial) mergers, friendships between sellers of complements increase efficiency and friendships between sellers of substitutes decrease it.

This positive impact of friendships between sellers of complements is due to the hold-out problem (Cournot, 1897; Kominers and Weyl, 2011, 2012; Sarkar, 2017; Grossman et al., 2019; Bryan et al., 2019). Raising the price of one's product has a negative externality on the seller of a complement (lower demand) and on the demand side (higher prices, less trade). I find that friendships among sellers of complements internalize this externality and raise efficiency. This finding introduces a social network perspective into market design with complements.

This paper also contributes to the experimental literature on the effects of social relationships on economic decision-making. Previous experiments have exposed real-world friends (Leider et al., 2009, 2010; Goeree et al., 2010; Ligon and Schechter, 2012; Chierchia et al., 2020) and participants sampled from real-world social groups (Goette et al., 2006; Baldassarri and Grossman, 2013; Finseraas et al., 2019; Gächter et al., 2022, 2023) and social networks (Chandrasekhar et al., 2018; Breza and Chandrasekhar, 2019; Jain, 2020; Iacobelli and Singh, 2024) to a laboratory setting to test the effect of social relationships on cooperation, contract enforcement, and other behaviors. These experiments test the effect of social relationships on cooperation, contract enforcement, and other actions. I add to this literature by using paired friendships as building blocks of social networks in a market setting. This approach allows me to study the interplay between the product network described by complementarity and substitutability and the social network defined by friendships.

It also contributes to the experimental IO literature on oligopoly and tacit collusion.[7] A common strand in this literature is that especially under repeated interaction (e.g. Holt, 1995), with two firms (Huck et al., 2004), and with opportunities for pre-play communication (Cason and Davis, 1995; Fonseca and Normann, 2012), outcomes in laboratory oligopoly games are frequently less competitive than the Nash benchmark. This paper identifies an additional channel that can generate collusion-like outcomes even in

[7] For early work see e.g. Sauermann and Selten (1959); Hoggatt (1959); Fouraker et al. (1961); Friedman (1964); Dolbear et al. (1968) and more recently Selten et al. (1997); Franciosi et al. (1995); Huck et al. (1999); Offerman et al. (2002); Bosch-Domènech and Vriend (2003); Huck et al. (2001, 2004); Dufwenberg and Gneezy (2000); Fonseca and Normann (2012). For surveys and meta-analyses see e.g. Holt (1995); Engel (2006); Potters and Suetens (2013).

a one-shot interaction without communication: social relationships among competitors.

Consistent with the tacit-collusion literature,[8] I isolate the role of the *mode of competition* by holding the economic environment fixed (consumer preferences and the production technology) and varying only the strategic variable that firms choose: prices (Bertrand) versus quantities (Cournot). When behavior is evaluated in the strategic variable itself (prices in Bertrand, quantities in Cournot), friendship has a larger (more "collusive") impact in regimes with strategic complementarity (Cournot with complements or Bertrand with substitutes) than in regimes with strategic substitutability (Cournot with substitutes or Bertrand with complements). However, the Bertrand-Cournot contrast shrinks when outcomes are compared in a common metric, expressing both regimes in terms of all prices or all quantities, because switching the strategic variable changes the mapping from choices into outcomes as well.

1 Experimental Design

I conducted two laboratory experiments to estimate how pre-existing friendships between sellers affect outcomes in markets with substitutes and complements.[9] Here, I describe both experiments in a unified framework.

Figure 1 summarizes the experimental procedure. In Step 1 (Recruit pairs of friends), I recruited 440 participants in total (across 2 experiments). Specifically, 220 "anchor" subjects were invited from the BonnEconLab subject pool via hroot (Bock et al., 2014), and each anchor registered together with and brought one friend to the laboratory session. To encourage anchors to recruit an actual acquaintance rather than a convenience match, bringing a friend was incentivized using a trivia task following Leider et al. (2009).[10]

After recruitment, In Step 2 (Friendship survey), participants completed a short questionnaire about their relationship.[11] They then read the instructions of the experiment and answered comprehension questions to ensure understanding (Step 3.).[12]

[8]For substitutes, price competition is often more conducive to tacit collusion than quantity competition: "Bertrand colludes more than Cournot" (Suetens and Potters, 2007; Davis, 2011). A common interpretation is that, for substitutes, Bertrand competition features strategic complements, which can amplify cooperative incentives (Potters and Suetens, 2009; Mermer et al., 2021).

[9]I preregistered the design, analysis plan, hypotheses, and sample size for the land market (n=240) at `https://osf.io/5ytnz` and for the Singh and Vives (n=200) markets at `https://osf.io/p69sx/files/osfstorage/6873dbfcfa089869f66c015d` . Any analyses that were not preregistered are clearly labeled as exploratory in the text.

[10]I announced that participants could earn an additional 5 euros for correctly answering a trivia question about their friend. At the beginning of the experiment, participants were asked when they usually get up and when their friends usually get up. Then, participants could enter their and their friend's wake-up times in one-hour brackets that reach from 5 to 11 a.m. They won 5 euros if they guessed the correct bracket for their friend's wake-up time. To avoid participants preparing for this question, I later switched it to another question: "Is your friend a vegetarian?"

[11]For more information on the friendship survey, see the discussion in Section 3 and the questionnaire in Appendix C.

[12]For a list of comprehension questions, see Appendix D.

In Step 4, participants made decisions in one of two experiments. In each experiment, they played a sequence of one-shot market games. Participants received no feedback and could not communicate, to avoid repeated-game effects.

In the *Duopoly* experiment, participants were assigned to either the Bertrand or the Cournot condition. Within each condition, they played several differentiated-products games in which goods were either complements or substitutes, and they played each game once with a friend and once with a stranger.[13]

In the *Network* experiment, participants played a four-player land-market game in which the market environment was held constant while the social network varied across treatments (friendships between substitute sellers, friendships between complement sellers, and asymmetric networks). The Network experiment also includes additional treatments to probe mechanisms; these are described in Section 1.2.[14]

Step 5 (Feedback and payment) concluded the session: after all decisions were completed, participants received feedback, answered open-ended questions, and were paid.[15]

Variation occurs both within and between subjects. In the *Duopoly* experiment, the identity of the opponent (friend vs. stranger) varies within subject, while the mode of competition (Bertrand vs. Cournot) is assigned between subjects. In the *Network* experiment, participants make decisions for multiple subsidy levels within subject, while network structure (and, in some treatments, price transparency; see Subsection 1.2) varies between subjects. The remainder of this section goes into more detail on the main task, by explaining the *Duopoly* and *Network* experiments and concludes with a discussion of the decision screen.

[13]The order of games is randomized at the session level. Subjects randomly either always play the version with friends first or always play the version with strangers first.

[14]I take several measures to minimize order effects and minimal group effects (see Appendix F for a detailed description).

[15]The full instructions for the building condition are reproduced in Online Appendix E. All instructions for the *Duopoly* experiment that differ from those are reproduced in Online Appendix F. I omitted several implementation details from the preceding discussion. The experiment was conducted in German and implemented in oTree (Chen et al., 2016).

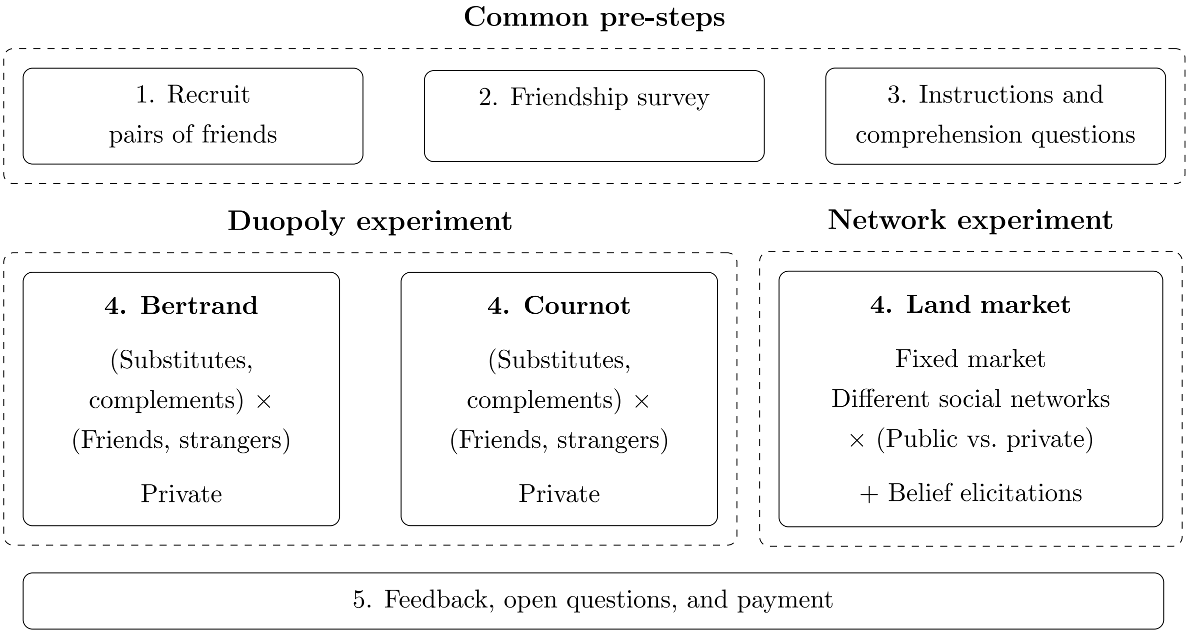


Figure 1: Experimental stages and treatment arms. Participants complete the common pre-steps (1–3), then take part in exactly one experiment (4), and finally provide feedback and get paid (5).

1.1 Duopoly Experiment

The Duopoly Experiment tests whether and how pre-existing friendships change strategic behavior in standard two-firm product-market settings. By embedding friend-versus-stranger interactions in canonical differentiated-products duopoly games, the experiment allows direct comparison to a large experimental IO literature (e.g. Suetens and Potters, 2007; Davis, 2011; Anderson et al., 2010; Van Essen and Hankins, 2013; Huck et al., 2000).

Using parameterizations of the differentiated-products framework in Singh and Vives (1984), subjects are assigned to either Bertrand or Cournot competition and play six versions of the game.[16] Each subject plays every version twice—once with their friend and once with a stranger—with substitutes in half the games and complements in the other half. After arriving at the lab together, pairs complete the preliminary steps shown in Figure 1 before assignment.

The experiment tests whether the familiar finding that Bertrand markets exhibit more collusion than Cournot markets (Suetens and Potters, 2007) also extends to the effect of friendship on collusive behavior. Its design disentangles (i) the effect of framing the strategic variable as prices versus quantities while holding the underlying game fixed, from (ii) the effect of changing the mode of competition itself, which alters the game's parameters.

[16] I induce all material components of the model through monetary rewards (Smith, 1976). Rewards are denoted in the experimental currency unit, thaler.

All decisions in the experiment can be represented by the following abstract game. In each round, players $i \in \{1, 2\}$ simultaneously choose a strategy $s_i \in \left[0, -\frac{a}{b} + 4\right]$. Profits (in thaler) are given by

$$\pi_1(s_1, s_2) = s_1\big(a + b\, s_1 + c\, s_2\big), \tag{1}$$
$$\pi_2(s_2, s_1) = s_2\big(a + b\, s_2 + c\, s_1\big), \tag{2}$$

where the coefficients (a, b, c) vary across rounds as reported in Table 1. In each round, participants are shown the corresponding values of a, b, and c. The same choice variable s_i is labeled either as a *price* (Bertrand competition) or as a *quantity* (Cournot competition).

Table 1: Parameter sets and economic interpretation.

Environment	Market interpretation	a	b	c
A	Cournot (Substitutes) / Bertrand (Complements)	30	$-\frac{8}{3}$	$-\frac{2}{3}$
B	Cournot (Substitutes) / Bertrand (Complements)	30	$-\frac{8}{3}$	$-\frac{4}{3}$
C	Cournot (Substitutes) / Bertrand (Complements)	20	-0.6	-0.4
A	Bertrand (Substitutes) / Cournot (Complements)	9	-0.4	0.10
B	Bertrand (Substitutes) / Cournot (Complements)	7.5	-0.5	0.25
C	Bertrand (Substitutes) / Cournot (Complements)	20	-3.0	2.00

Figure 2 illustrates how alternative parameterizations of the abstract game correspond to Bertrand or Cournot competition with substitutes or complements. The top starts with games of strategic substitutes (implemented as Cournot with substitutes and its dual, Bertrand with complements), obtained by choosing $c < 0$. Applying the duality result in Singh and Vives (1984) switches the mode of competition while holding the underlying economic environment constant, and in doing so flips the game from strategic substitutes to strategic complements. Switching between price and quantity competition in the same row changes only the interpretation of the strategy s_i (as shown in the equations beneath each parameter table).

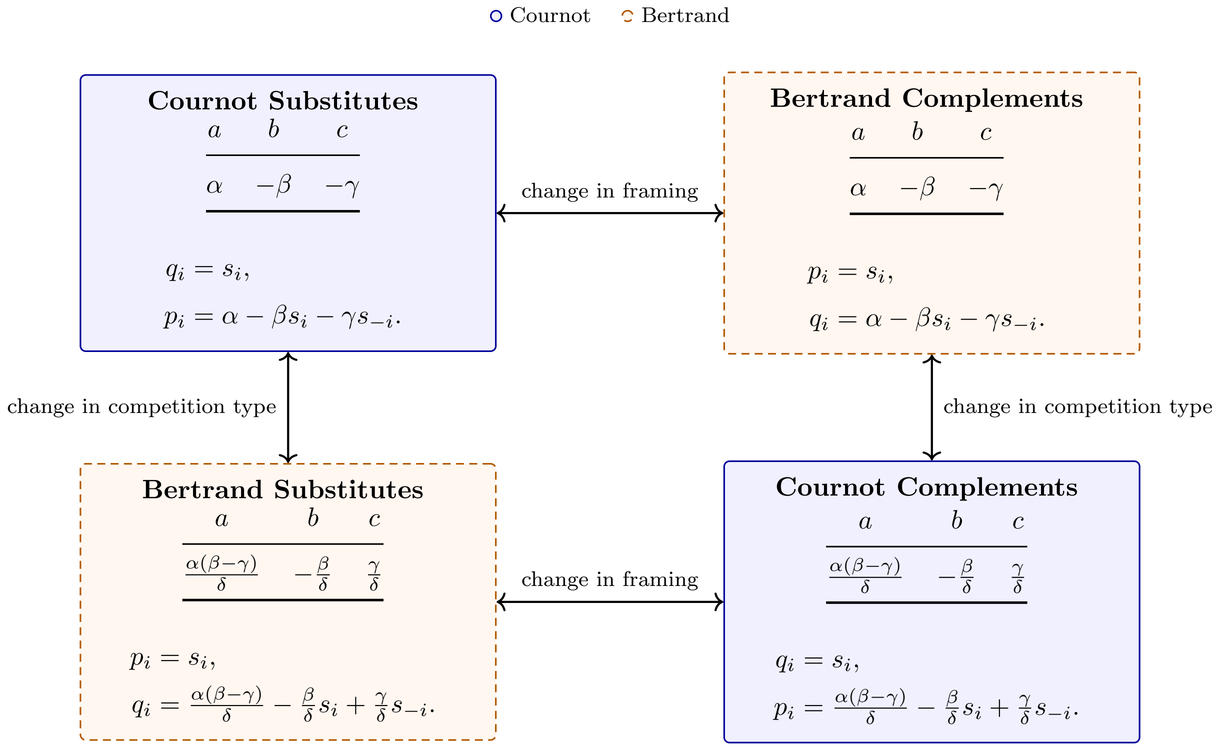


Figure 2: Relationship between different price and quantity games in the Singh and Vives framework. The profit is given by $m(s_1, s_2) = s_1 \cdot (a + bs_1 + cs_2)$. Define $\delta = \beta^2 - \gamma^2$. We assume that $\alpha, \beta, \gamma > 0$ and $\beta > \gamma$

Participants assigned to the Cournot condition play six games. They first play three Cournot Substitutes games (Rows 1–3 in Table 1), corresponding to the top-left box (solid outline) in Figure 2. They then play three Cournot Complements games (Rows 4–6), corresponding to the bottom-right box.

Participants assigned to the Bertrand condition also play the same six parameterizations, but interpreted as price competition: Rows 1–3 are Bertrand Complements (top-right) and Rows 4–6 are Bertrand Substitutes (bottom-left). These appear on the off-diagonal of Figure 2 (dashed boxes).

The effect of labeling a strategically equivalent game as Cournot versus Bertrand is identified through a between-subject comparison of the corresponding equivalent games. The effect of changing the mode of competition itself—which changes the game's parameters is identified by comparing games in the top row of Figure 2 to those in the bottom row.

1.2 Network Experiment

The *Duopoly* experiment varies two dimensions: the relationship between the two goods (complements vs. substitutes) and the relationship between their sellers (friends vs. strangers). Changing the goods relationship shifts demand, which makes welfare comparisons between complement and substitute friendships difficult. To address this, I run an additional experiment in a four-player differentiated-products Bertrand market in which products can be both substitutes and complements. This *Network* experiment holds the market environment fixed and varies only the social network among sellers, allowing me to compare behavior when (i) all sellers of complements are friends, (ii) all sellers of substitutes are friends, and (iii) networks are asymmetric, with one pair of friends and the other two sellers strangers. To make the richer strategic environment easier to understand, I frame the game as a land market in which the complement and substitute relationships map naturally onto a familiar real-world setting.

The participants play one of four sellers who sell land to a computerized buyer. The sellers' 1 and 2 own land on the left side of a river, and the sellers' 3 and 4 own land on the right side (see Figure 3). Sellers make simultaneous take-it-or-leave-it price offers. The offer of the seller i is denoted p_i, $i \in \{1, 2, 3, 4\}$. Offers are restricted to integers between 0 and 50.

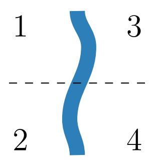


Figure 3: Endowment of plots in the *Network* game. Plots on the same side of the river are complements; plots on different sides of the river are substitutes.

The buyer wants to build a single building that spans two plots on the same side of the river. He has private valuations that are independent draws from identical uniform distributions θ_ℓ and θ_r for two plots on the left and right sides, respectively. The value distribution's support reaches from 0 to 100. Sellers' take-it-or-leave-it offers are aggregated ($p_\ell = p_1 + p_2$ and $p_r = p_3 + p_4$) and transmitted to the buyer. The buyer buys the bundle of land that gives him the highest surplus ($\theta_\ell - p_\ell$ or $\theta_r - p_r$) if this surplus is positive. Sellers may receive a subsidy $S \in [0, 20]$ for successful sales.

If a participant sells, her profit (π_i) is her price plus the subsidy; in all other cases, it is zero. The probability that the buyer buys on the left side is $Pr_\ell(p_1, p_2, p_3, p_4) = Pr(\theta_\ell - p_1 - p_2 > \theta_r - p_3 - p_4 \wedge \theta_\ell - p_1 - p_2 > 0)$. Consequently, the profit of player 1 is

$$\pi_1(p_1, p_2, p_3, p_4) = Pr_\ell(p_1, p_2, p_3, p_4)(p_1 + S).$$

The other players' pay-offs (π_2, π_3, π_4) are defined analogously.

I asked participants to make choices in slightly varying market environments to increase statistical power. While keeping all other variables, including the treatments, constant, participants had to decide on prices for five possible subsidies (S), ranging from 0 to 20 thaler.

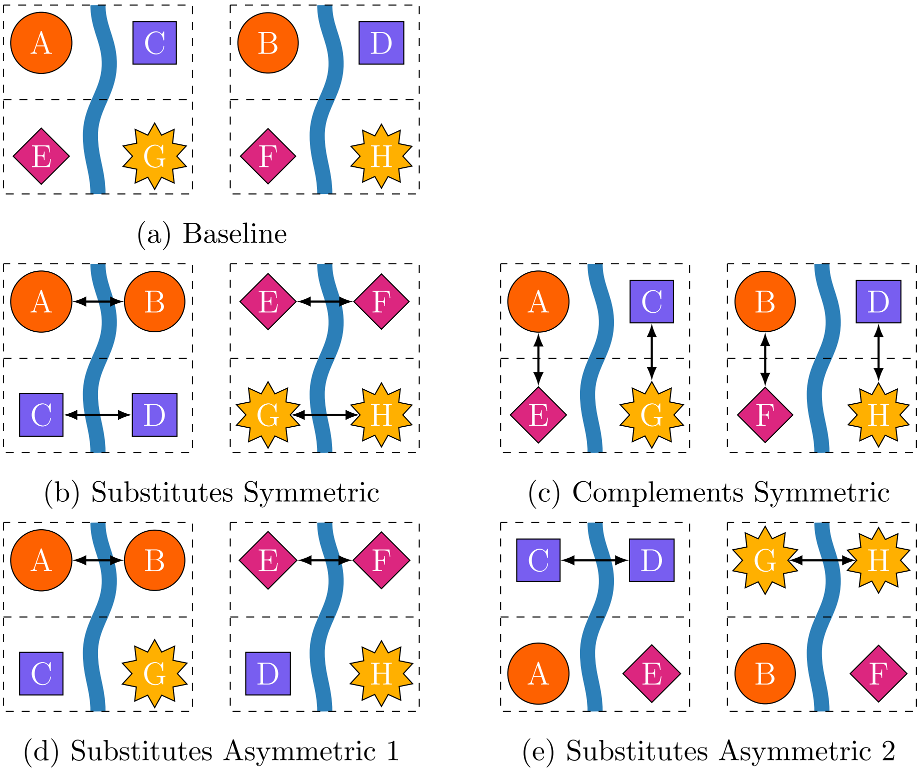


Figure 4: Assignment of friendship pairs to the experimental market for different social network treatments. Each panel depicts the full allocation of participants to markets for one type of round in the experiment with 8 participants. Each colored node represents one participant. Friends are indicated by consecutive letters and a common shape of their node.

To implement different social networks while keeping the market environment fixed, I varied which sellers within a four-player market were friends. I consider a baseline assignment with no within-market friendships, two symmetric networks in which friendships connect either sellers of substitutes or sellers of complements, and asymmetric networks in which only one pair of sellers is friends.

Figure 4 illustrates the assignment logic. Each panel depicts a stylized version of the experimental lab consisting two diagrams of the experimental market. Participants who are friends share shapes and colors and have consecutive letters assigned to them. Participants are depicted in the spot of the player whose role they have been assigned.

Figure 4 illustrates the *Baseline treatment*. I invited 4 pairs of friends and split them into two markets. From each pair, one participant takes part in the market on the left, and the other does so in the market on the right. This assignment results in two markets without social relationships within a market.

Contrast the Baseline treatment with the *Substitutes Symmetric* treatment in Figure 4b. In this case, pairs are assigned to the same market on opposite sides of the river. This assignment results in two friendships among sellers of substitutes in each market. These friendships are indicated by bidirectional arrows. Analogously for the Complements

Symmetric treatment, I assign friendship pairs to the same side of the river (see Figure 4c).

In the *Substitutes Asymmetric* network (Figure 4d) I assign one friendship pair to each of the two markets on opposite sides of the river and split up the remaining pairs (C–D and G–H) across the two markets. In this case, the pairs that were not split up (A–B, and E–F) received the *Substitutes Asymmetric: Pair* treatment. The pairs that were split up received the *Substitutes Asymmetric: Isolated* treatment. I complement this network by its mirror image depicted in Figure 4e.

I aim to disentangle intrinsic altruism from social sanctions by varying *price transparency*: In the *public*, treatment prices could be revealed at the end of the experiment, and in the *private* treatment, they always stayed private. In both treatments, there was no feedback in between decisions. I omit the private condition for the asymmetric networks. The *Duopoly* Experiment only includes the *private* treatment.

In the feedback and payout step (Step 7 in Figure 1) If the computer selected a decision from the public treatment for payout, participants learned all prices, their monetary profit, and (in the *Network* experiment) which plots were sold. If a decision from the private treatment was selected participants only received information about their payout.

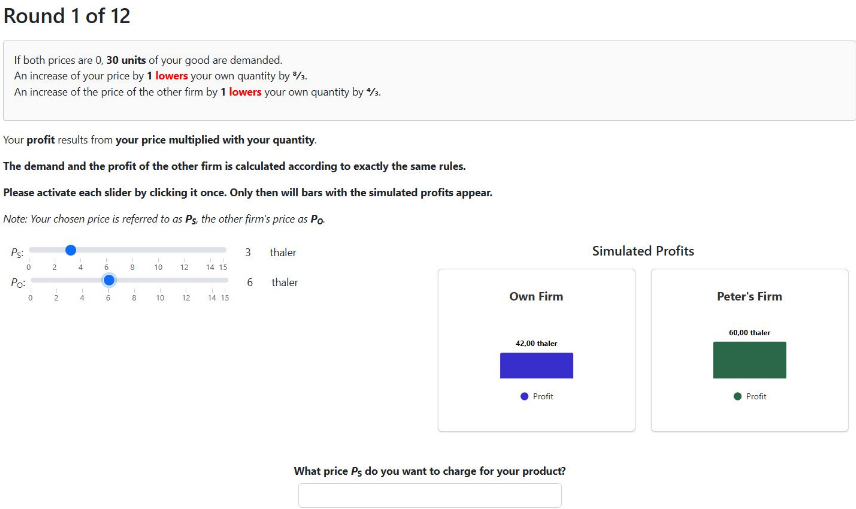
I elicited beliefs about other participants' prices using a binarized scoring rule[17] in all network treatments, for the public and private condition, but only for the zero-subsidy case ($S = 0$). For further details, see Appendix J.

1.3 Decision Interface

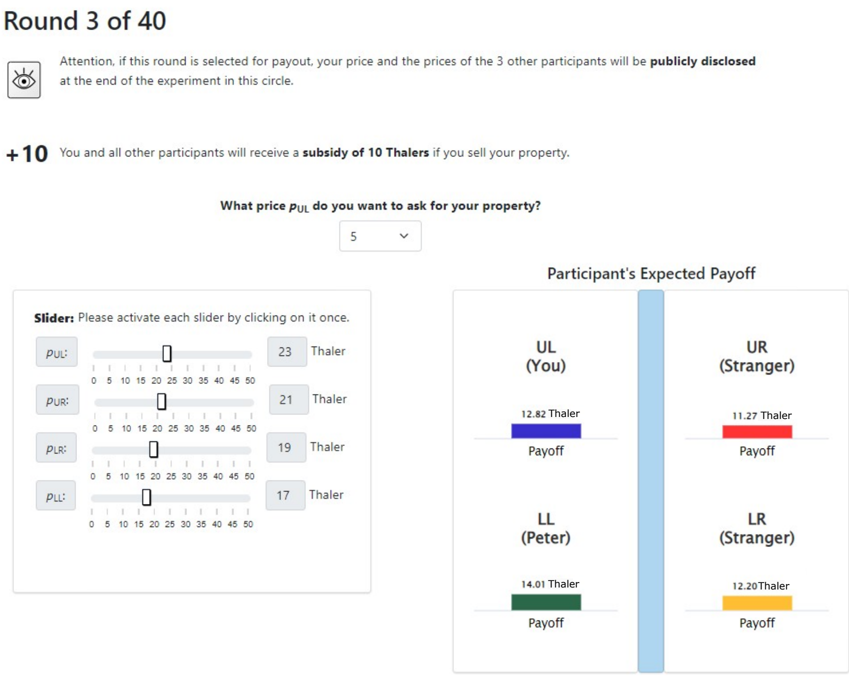
Before making any decisions, participants received information about the social relationships in the current condition. In the *Duopoly* experiment, they saw a sentence indicating whether they were playing with a friend or a stranger. In the *Network* experiment, they saw a diagram of the current network based on the map of the four plots. I identified the participant's friend using a nickname the participant had assigned. I also showed friendships between other players, but I did not reveal their names. In both experiments this information was repeated on the decision screen as well.

For an example decision screen, see Figure 5. The top of each screen provides information about the game parameters (*Duopoly* game: a, b, c; *Network* game: subsidy) and indicates whether the game is conducted under the public or private condition. Below this, participants could enter a strategy (price or quantity) and were provided with a decision aid to simulate the consequences of their own and others' decisions.

[17] Hossain and Okui (2013), following standard practices developed in response to Danz et al. (2022).



(a) *Duopoly* Experiment, $a = 30$, $b = -\frac{8}{3}$, $c = -\frac{4}{3}$.



(b) *Network* Experiment Public treatment; Substitutes Asymmetric: Pair; Subsidy = 10.

Figure 5: Translated decision screen used to elicit participant choices.

The decision aid is intended to reduce decision errors. It calculates each player's expected profit for every possible combination of players' strategies. Participants were given one slider for each player's strategy, including their own. Bar charts and numerical displays indicated the corresponding expected profits for each participant. By adjusting the sliders, participants could simulate how changes in their own and others' strategies affected everyone's expected profits.

2 Predictions

In this section, I apply the simplest model of friendship-driven cooperation—a linear directed-altruism model (Edgeworth, 1881; Leider et al., 2009)—to derive predictions for how different social networks affect prices. The theory builds on a standard result in the theory of Industrial Organization: Mergers among sellers of complements increase efficiency, while mergers among sellers of substitutes decrease it (Cournot, 1897).

The model allows us to define each player's utility as a function of all players' material payoffs. Let $N \in \{2, 4\}$ denote the number of players, and let $\boldsymbol{s} = (s_1, \ldots, s_N)$ denote the strategy profile. Let $\pi_i(\boldsymbol{s})$ denote player i's monetary profit. Preferences exhibit linear directed altruism: each player i has at most one friend participating in the game, denoted by $f(i) \neq i$, and places weight $\mu \in [0, 1]$ on that friend's profit. Player i's utility is

$$u_i(\boldsymbol{s}) = \begin{cases} \pi_i(\boldsymbol{s}) + \mu\, \pi_{f(i)}(\boldsymbol{s}) & \text{if player } i \text{ plays with a friend,} \\ \pi_i(\boldsymbol{s}) & \text{otherwise.} \end{cases}$$

Directed altruism makes friends partially internalize the profit externalities they impose on one another. The sign of these externalities depends on whether the friends products are substitutes or complements. This logic yields Prediction 1; based on several propositions that are formally stated and proven in the Appendix.[18] Here I provide a brief intuition.

Prediction 1 (Effect of friendships on markets.). Relative to strangers, friendships among sellers of substitutes increase equilibrium prices, lower equilibrium quantities and lowers overall surplus, whereas friendships among sellers of complements have the reverse effect.

Bertrand competition. When a seller raises her price, this affects the demand for related goods differently depending on the relationship between the goods. If the goods are *substitutes*, the other seller's demand increases, so a higher price creates a *positive externality* on the other seller. If the goods are *complements*, the other seller's demand decreases, so a higher price creates a *negative externality* on the other seller.

When sellers are friends, they internalize these effects. A seller with a friend selling a *substitute* raises her price to increase her friend's demand. By contrast, a seller with a friend selling a *complement* lowers her price to support her friend's demand. Since demand falls as prices rise, quantities move in the opposite direction.

[18] The comparative-static predictions for prices and quantities in the *Duopoly* and prices *Network* games are formally established in the appendix: For the *Duopoly* game, they follow from Proposition 2 in Appendix A; for the *Network* game, they follow from Propositions 3 and 4 in Appendix B. By contrast, I do not provide a formal result for quantities in the network game, because the model features a probability of sale rather than a quantity choice. I also do not provide a formal proof for the efficiency result, as the conclusion is largely straightforward but the derivation is tedious.

Cournot competition. Here, sellers choose quantities rather than prices, so the relevant externalities operate through quantities. A higher quantity imposes a *negative externality* on sellers of *substitutes* (because it intensifies competition), but a *positive externality* on sellers of *complements* (because it increases demand for related goods).

When these externalities are internalized through friendship, sellers of *substitutes* reduce their quantities, while sellers of *complements* increase theirs. Since inverse demand falls with total quantity, prices move in the opposite direction: Friendships among sellers of substitutes increase prices, while friendships among sellers of complements decrease prices.

Efficiency is evaluated in terms of total surplus (producer plus consumer surplus). In standard imperfect competition with positive markups, equilibrium prices are above the efficient (first-best) benchmark. If total surplus is globally concave as a function of prices, then moving prices downward increases total surplus, while moving prices upward decreases it. Hence, friendships among sellers of complements increase total surplus, while friendships among sellers of substitutes decrease total surplus.

We can also interpret the efficiency effects by examining the direction of the externalities. In friendships among substitutes, high prices benefit friends but harm consumers. For complements, low prices benefit the friends and the consumer. Hence, in the second case, friendship is likely welfare improving, while in the first case it is not.

The asymmetric networks in the *Network* experiment allow me to isolate how introducing a friendship between two sellers affects the behavior of third parties. Figure 6 illustrates the identifying comparison.

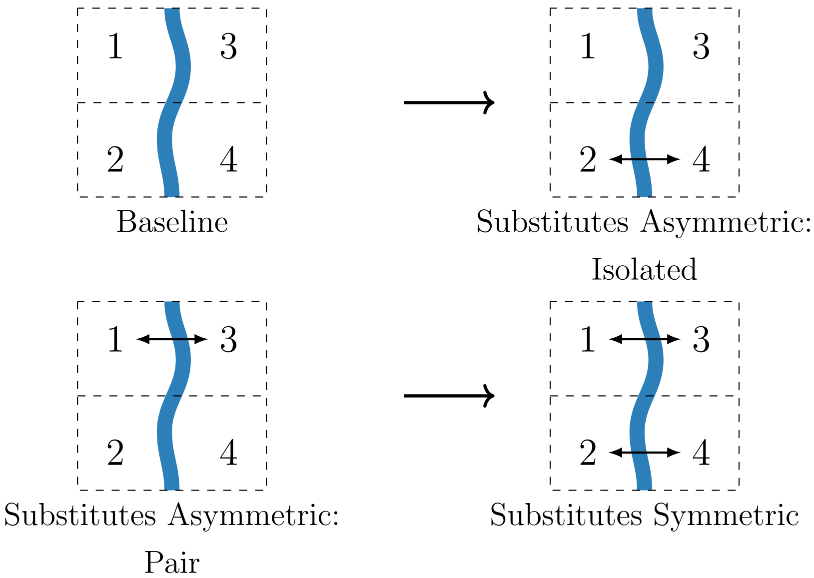


Figure 6: Theoretical comparison underlying Prediction 2.

The figure depicts the treatment pairs used to estimate spillovers from a single friendship. The two panels differ only in the relationship between players 2 and 4: On the left they are strangers, while on the right they are friends. The social relationships involving players 1 and 3 are held fixed across panels. Recall that players on opposite sides of the river sell substitutes. Prediction 2 states the resulting implication of a friendship between players 2 and 4 for the prices set by players 1 and 3.

Prediction 2 (Spillovers). Friendships among sellers of substitutes lower the prices of products that are complements to the friends' products.

Applied to Figure 6, the prediction implies that the prices set by players 1 and 3 decrease when the friendship between players 2 and 4 is introduced. A formal statement and proof appear in Proposition 4 in Appendix B. Here, I provide intuition, abstracting from second-round equilibrium effects.

To discuss the equilibrium effects of this friendship, I need to determine which prices are strategic complements and which are strategic substitutes. When one player raises her price, the other player on the same side of the river will lower his price to offset the overall increase in total price. On the other hand, a player selling a substitute experiences less competitive pressure and can raise her price. In essence, the prices of complements are strategic substitutes, while the prices of substitutes are strategic complements.

Since players 2 and 4 sell substitutes, their friendship leads to an upward shift in their best responses. This shift has two opposing effects on the price set by player 1. Player 1's product is a complement to player 2's product and a substitute for player 4's product. Due to strategic substitutability, an increase in player 2's price will decrease player 1's price. Conversely, due to strategic complementarity, an increase in player 4's price will increase player 1's price. For the parameters of this game the former effect dominates the latter.[19] Therefore, the friendship of players 2 and 4 lowers the price of player 1. Symmetrically, this also reduces the price for player 3.

I use the *Duopoly* game to analyze the effect of changing the mode of competition. Recall that we can write the profits as a function of strategies (prices or quantities) as

$$\pi_i(s_i, s_{-i}) = s_i \cdot (a + b \cdot s_i + c \cdot s_{-i}) \quad a \in \mathbb{R}_{>0}, b \in \mathbb{R}_{<0}, c \in \mathbb{R} \tag{3}$$

Switching from Bertrand to Cournot competition changes two things: (1) the strategy variable changes from price to quantity, and (2) the parameterization changes (i.e., the values of (a), (b), and (c)).

We can isolate labeling effects by comparing participants' choices in games with identical parameters but different labels (i.e., strategies labeled as prices or quantities). In

[19]The influence of strategic substitutability surpasses that of strategic complementarity because of the higher cross-price elasticity between complements.

this setting, the directed-altruism model does not yield a distinct prediction. Moreover, I am not aware of any experiment that compares Cournot and Bertrand frames while holding the underlying game fixed.[20] Accordingly, I test the hypothesis that changing the strategy labels does not moderate the effect of friendship on behavior. We summarize this in Prediction 3.

Prediction 3 (Label invariance). Expressing an identical game as Cournot rather than Bertrand competition does not affect the effect of friendship on strategies.

For the change in parameters refer to Figure 2 in Section 1. In the top row we start with a Cournot Substitutes game or a Bertrand Complements game that has the following profit function,

$$\pi_i(s_i, s_{-i}) = s_i \cdot \underbrace{\Big(\alpha - \beta s_i - \gamma s_{-i}\Big)}_{\text{inverse demand / demand}} \qquad \alpha, \beta, \gamma \in \mathbb{R}, \beta > \gamma.$$

where for Cournot substitutes the term in brackets is the inverse demand and for Bertrand complements that term is the demand. Here a player's demand is falling in the other player's strategy. This implies that strategies are strategic substitutes and that the externality of choosing a higher value is negative. In market games these two variables can usually not be disentangled (Potters and Suetens, 2009).

When we change the mode of competition we invert the demand or inverse demand and reach the following profit function.

$$\pi_i(s_i, s_{-i}) = s_i \cdot \underbrace{(1/\delta)\Big((\beta - \gamma)\alpha - \beta s_i + \gamma s_{-i}\Big)}_{\text{inverse demand / demand}} \quad \alpha, \beta, \gamma \in \mathbb{R}, \beta > \gamma, \delta = \beta^2 - \gamma^2.$$

Aside from scaling the inverse demand by $1/\delta$, we also change the constant term in the inverse demand and flip the sign on the coefficient multiplying the other player's strategy. As a result of this sign flip, externalities become positive and strategies become strategic complements.

When strategies are strategic complements the effect of altruism among friends is amplified. Since externalities are positive, a friendship among players increases strategies. Due to strategic complementarities and increase in one players strategy will also lead to an increase in the other player's strategy and so on until equilibrium is reached.[21]

For high levels of the altruism parameter μ the described enhancement effect of strate-

[20] Masiliūnas and Nax (2020) find that framing games of strategic complements as Cournot competition increases cooperation, but they do not find such an effect for strategic substitutes.

[21] Similarly, in repeated-game and laboratory market settings, strategic complementarity often enhances cooperation by making cooperative deviations mutually reinforcing through best responses (Holt, 1995; Suetens and Potters, 2007; Davis, 2011; Potters and Suetens, 2009; Mermer et al., 2021; Güth et al., 2016; Yang and Potters, 2025), though some designs find weaker or reversed patterns (Anderson et al., 2010; Van Essen and Hankins, 2013).

gic complementarity dominates. However for lower levels of altruism this effect can be reversed by the other changes to the profit function. So far we have discussed the effect in the strategy space, which is prices for Bertrand and quantities for Cournot. If we transform either all strategies into prices are all into quantities, using the inverse demand or demand relationship the effect gets further attenuated in the sense that μ has to be even higher for it to be true. I summarize this argument in Prediction 4 and state it formally and prove it in Proposition 2 in Appendix A.

Prediction 4 (Changing mode of competition). Changing the mode of competition from one where strategies are strategic substitutes (Cournot with Substitutes or Bertrand with Complements) to one where strategies are strategic complements (Cournot with Complements or Bertrand with Substitutes) likely increases the effect of friendship on strategies (Bertrand prices or Cournot quantities). When analyzed in terms of quantities for all games or prices for all games the friendship effect is less likely to be amplified.

3 Empirical Results

I start this section by presenting manipulation checks to verify that the experiment captures meaningful real-world friendships. I then test the implications of the directed-altruism model developed in Section 2. With the exception of strategic spillovers from third-party friendships—which are not supported in the data—the model's predictions are borne out in the experiment. Next, I uncover the if the mechanisms behind participants' cooperative behavior is intrinsic altruism or driven by social sanctions. I then evaluate an alternative explanation—greater familiarity between friends—distinct from directed altruism. I find no evidence for an increase in directed altruism behavior due to price transparency and rule out familiarity as an alternative theory. I conclude by structurally estimating the altruism parameter and find that $\mu \approx 0.3$ rationalizes observed behavior and treatment effects across both experiments and all treatments, except those designed to detect strategic spillovers.

As a first step, I establish that the experimental friendship manipulation is meaningful. I therefore conduct manipulation checks to verify that participants had close friendships and understood the experiment.

My primary measure of friendship closeness is the inclusion of the other in the self (IOS) scale (Aron et al., 1992). This scale asks participants to pick one of seven pictures with overlapping rings that best describe their friendship. These pictures range from (1) no overlap to (7) almost complete overlap. Gächter et al. (2015) find that the IOS measure correlates strongly with six other measures of relationship closeness. I asked four additional survey questions as an alternative measure of friendship closeness (see Appendix C for the questionnaire).

The survey's results suggest that participants have meaningful social connections with their friends (see Table 5 in Appendix C). Participants have an average value of 5 on the IOS scale. This value compares to 3.7 for friends and 5.7 for close friends in Gächter et al. (2015). Participants spend, on average, 30 hours per week with their friends, in contrast to the slightly below twenty hours found by Goeree et al. (2010), who find strong effects of friendship on dictator game contributions.

Comprehension questions tested participants' knowledge about the cross-price derivatives of demand (for additional details, see Appendix D). For example (fill in the blanks): "The probability that you sell your plot of land [rises/falls] if player LL increases their price." I asked 5 questions of this type. In the *Duopoly Experiment*, participants answered an average of 4.5 out of 6 questions correctly, and approximately 38% answered all questions correctly. In the *Network Experiment*, participants answered an average of 4.8 out of 5 questions correctly, and approximately 88% answered all questions correctly. After each batch of comprehension checks, I gave participants feedback that corrected the wrong answers.

3.1 Testing The Implications of Directed Altruism

At the outset, Table 2 summarizes the testable implications of directed altruism, the experimental comparisons used to test each prediction, and the corresponding results. The remainder of this subsection discusses each prediction in turn.

I estimate the effect of introducing friendships (Prediction 1) by comparing each treatment with friends to its corresponding baseline treatment without friends. In the *Duopoly* experiment, I organize the analysis using the Bertrand product-market framing: markets with $c > 0$ are labeled *substitutes* (Bertrand substitutes) and markets with $c < 0$ are labeled *complements* (Bertrand complements). Within each category, I compare otherwise identical markets with friends to markets without friends.[22] In the *Network* experiment, the product market is held fixed; I vary the location of friendships (between substitutes vs. complements) without changing the underlying market structure. Unless otherwise specified, I estimate all effects using OLS with standard errors clustered at the friendship-pair level.[23]

Empirically, complement friendships lower prices, and substitute friendships increase prices. Figure 7 depicts the estimated causal effect of friendships on prices. The horizontal axis shows the experimental condition, the vertical axis shows the estimated effect of friendship on thaler prices, and the color indicates whether the friendship was among sell-

[22]For ease of presentation, I pool the two strategy labels (Bertrand and Cournot) by mapping Cournot-complements markets into the Bertrand-substitutes ($c > 0$) category and Cournot-substitutes markets into the Bertrand-complements ($c < 0$) category.

[23]See Appendix G.

Table 2: Predictions, key comparisons, and results.

P	Exp.	Key comparison	Res.
1	D,N	**Duopoly:** (i) Friends–Strangers in substitutes ($c > 0$); (ii) Friends–Strangers in complements ($c < 0$). **Network:** (i) Substitutes Symmetric − Baseline; (ii) Complements Symmetric − Baseline.	✓
2	N	**Spillovers:** (Substitutes Asymmetric: Isolated + Substitutes Symmetric) − (Baseline+Substitutes Asymmetric : Pair).	×
3	D	**Label invariance:** strategically equivalent game labeled *price* vs. *quantity*; test Friends×Label (within $c > 0$ and $c < 0$).	✓
4	D	**Mode of competition:** compare the magnitude of the friendship effect under strategic complements vs. strategic substitutes; then re-express outcomes in a common metric (all prices / all quantities) and re-test amplification.	✓

Legend: D=Duopoly; N=Network; Baseline=no friendship links. ✓supported; × not supported. *Network treatments:* Symmetric Substitutes, Symmetric Complements, Asymmetric Substitutes (Pair), Asymmetric Substitutes (Isolated).

ers of complements or substitutes.[24] Across all treatments and experiments, friendships among sellers of substitutes increase prices, and friendships among sellers of complements decrease prices. In the *Network* game, I also elicit beliefs and find that participants' beliefs about others' prices move in the same direction as the corresponding prices (See Figure 16 in Online Appendix A).

I follow two approaches to quantify the magnitude of the effect.[25] I use a normalized measure of collusion (Engel, 2006; Suetens and Potters, 2007) and estimate the altruism parameter μ implied by participants' choices (see the structural estimates in Subsection 3.3).

The normalized collusion measure is calculated as follows: for each game g, I compute the joint-payoff-maximizing price p_g^{JPM}, i.e., the price that would result if friends maximized the sum of their profits ($\mu = 1$).[26] I also compute the Nash equilibrium price under

[24] My analysis deviates from the preregistration by presenting coefficient plots with 95% confidence intervals instead of one-sided t-tests.

[25] Both of these analyses are not pre-registered.

[26] In the Network experiment, the joint-payoff-maximizing benchmark and thus the normalization range ($p_g^{JPM} - p_g^{Nash}$) depends on the network structure, whereas the baseline condition is common across Network games. I therefore evaluate baseline decisions against the appropriate network-specific p_g^{JPM} (and cost-specific p_g^{Nash}) by replicating baseline observations across network conditions within each cost level and recomputing the normalized measure; baseline behavior is unchanged in levels, but its normalized value can differ across networks because the benchmark range differs.

selfish play, p_g^{Nash}. Let $p_{i,g}$ denote participant i's price choice in game g. The normalized collusion measure is then

$$\frac{p_{i,g} - p_g^{Nash}}{p_g^{JPM} - p_g^{Nash}}.$$

I then estimate a pooled regression comparing this measure for decisions made with friends to the corresponding decisions made without friends.[27] The pooled coefficient estimate is 0.82, with a 95% confidence interval of [0.65, 1.00]. Interacting with friends shifts outcomes toward the joint-payoff-maximizing benchmark by about 82% of the distance from the Nash outcome.

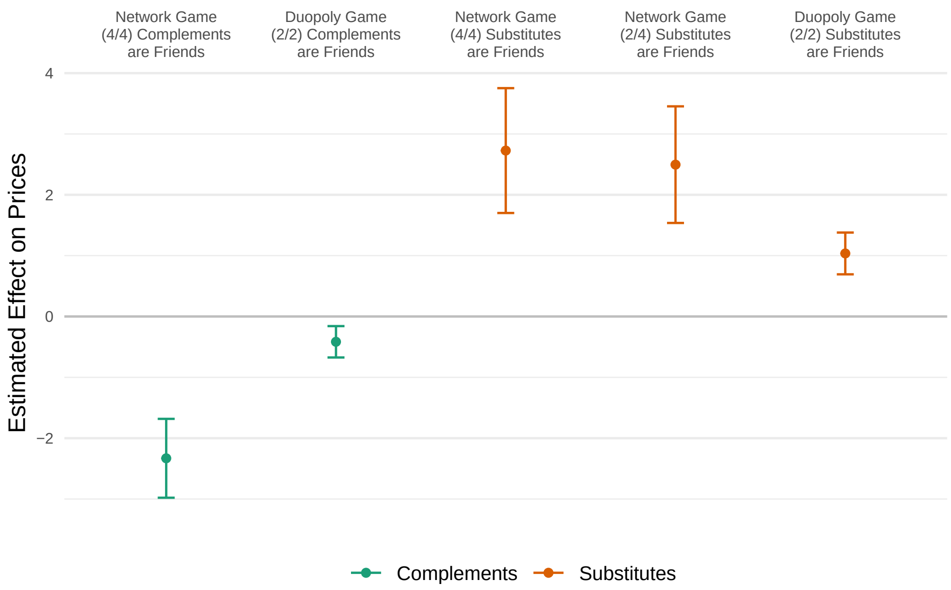


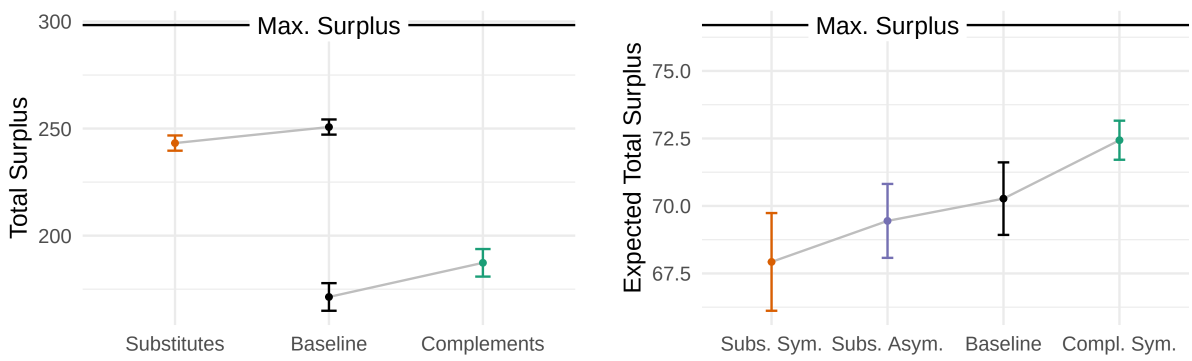
Figure 7: Estimated effects of friendships among sellers of complements and substitutes. The x-axis includes information about the experiment (*Duopoly* vs *Network*, which type of friendship manipulation was conducted (Complements vs. substitutes) and how many participants are affected by it (e.g. 2/4 in the Substitutes Asymmetric game). Standard errors are clustered at the friendship-pair level. Error bars indicate 95% confidence intervals. For the *Duopoly* experiment, each analysis includes 1200 observations from 200 participants × 2 friendship treatments × 3 markets. For the *Network* experiment each analysis includes 4800 observations from 240 participants × 2 networks × 2 transparency treatments × 5 subsidy levels.

After establishing that friendships shift prices in the expected direction, I turn to the welfare consequences of these shifts within the market. I measure producer surplus using expected seller profits in the experiment and consumer surplus using the computerized buyer's (theoretical) expected utility.[28]

[27] I exclude players without friends in the asymmetric Network condition. Standard errors are clustered at the friendship-pair level, which accounts for the replicated Baseline observations.

[28] In the *Duopoly* experiment, consumer surplus is computed from the underlying utility function in Singh and Vives (1984); here "expected" is redundant because there is no uncertainty. In the *Network*

Figure 8 reports average expected total surplus by experiment and treatment. For reference, it also shows the average maximum surplus (computed by setting prices to zero). Points denote mean surplus for each treatment; error bars show 95% confidence intervals based on standard errors clustered at the session level. The horizontal line indicates the maximum attainable surplus. Data from the same market environment but with different social relationships is connected using the gray lines.



(a) *Duopoly* experiment, 200 participants, 39 sessions

(b) *Network* experiment, 240 participants, 29 sessions

Figure 8: Average total surplus for all experimental conditions. Confidence intervals are 95%. Standard errors are taken from a treatment-cell-wise linear regression of surplus on a constant, with standard errors clustered by session.

Across both experiments, friendships among sellers of complements increase efficiency, whereas friendships among sellers of substitutes reduce efficiency. The surplus decomposition in Appendix E helps clarify why. When products are complements, baseline prices are inefficiently high from both sellers' and buyers' perspectives, so friendship moves prices toward the efficient benchmark—raising seller surplus, buyer surplus, and total surplus. When products are substitutes, incentives are misaligned: Friendship raises seller surplus largely at the expense of buyer surplus, and the decline in buyer surplus outweighs the gain in seller surplus, reducing total surplus overall.

Prediction 2 states that forming a friendship between two sellers of substitutes should lead the sellers of the corresponding complements to set lower prices. Figure 6 shows how I test this: I compare outcomes in the Substitutes Asymmetric: Isolated and Substitutes Symmetric networks to those in Baseline and Substitutes Asymmetric: Pair. This contrast introduces a substitutes-friendship while holding the complements-side social relationship fixed.

Figure 9 reports the resulting treatment effects. As discussed previously (Figure 7), the friends' own prices increase. But contrary to Prediction 2, I find no evidence that

experiment, I take expectations over the computerized buyer's value distribution. I group the data by the treatments depicted in Figure 8 and average over all other conditions. When computing producer surplus in the *Network* experiment, I treat subsidies as part of the seller's cost function.

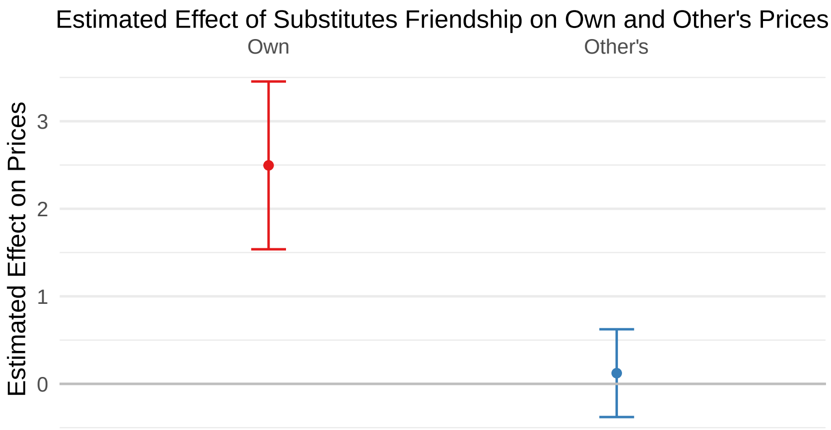


Figure 9: Estimated effects of substitute friendships on own and others' prices in the asymmetric substitutes network. Standard errors are clustered at the friendship-pair level. Error bars indicate 95% confidence intervals. I restrict the analysis to the networks with price transparency since (as preregistered) I did not collect data for asymmetric networks without price transparency. Each analysis includes 4800 observations from 240 participants × 4 networks × 1 transparency treatment × 5 subsidy levels.

this friendship spills over to the other players' prices. One interpretation is belief underreaction: Third parties do not sufficiently update their expectations when social ties change but are not experienced firsthand (see Appendix I).

Prediction 3 concerns a pure labeling manipulation: Holding participants' payoffs fixed[29], does labeling the choice variable as a *price* rather than a *quantity* change the effect of friendship? Under directed altruism, the answer is no—friendship changes how much weight participants place on others' payoffs, but it should not depend on whether the strategic choice is described as a price or a quantity.

To test this, I regress the chosen strategy on indicators for the price/quantity label, friends versus strangers, and their interaction. I estimate the specification separately for strategic complements and strategic substitutes. In both cases, the interaction term is statistically insignificant (strategic complements: $p = 0.69$; strategic substitutes: $p = 0.105$), indicating that the friendship effect does not depend on whether strategies are labeled as prices or quantities. Full regression results are reported in Table 7 in Appendix K.

A separate question is whether the *magnitude* of the friendship effect depends on the strategic environment. Prediction 4 posits that friendship effects are stronger when strategies are strategic complements than when they are strategic substitutes, because complementarity amplifies behavioral responses through best-response feedback.

I test this by regressing the chosen strategy on a friends indicator, an indicator for strategic complements, and their interaction. Switching from strategic substitutes to strategic complements substantially increases the estimated magnitude of the friendship effect (from roughly 0.4 to roughly 1), and an F-test rejects equality of the absolute

[29]The theoretical consumer surplus varies.

effects across regimes ($p \approx 0.009$). The underlying regression is reported in Table 8 in Appendix K.

While these results are informative about strategic mechanisms, the economically relevant comparison is in common outcome metrics (prices or quantities) holding the environment fixed. I therefore translate all choices into quantities and re-estimate the same interaction specification, separately for complements and substitutes. The coefficients have the predicted signs, but the interaction is statistically insignificant (complements: $p = 0.96$; substitutes: $p = 0.36$). Pooling the data and using a standardized cooperation measure yields the same conclusion.[30] Full results are reported in Table 8 in Appendix K.

3.2 Mechanisms and Alternative Theories

I test whether price transparency amplifies the effects of friendship by comparing prices in the Substitutes Symmetric and Complements Symmetric treatments with and without transparency. The idea is that sanction-based mechanisms require observability: if actions are transparent, friends can more easily discipline non-cooperation, which should strengthen friendship effects.[31] If this channel is important, transparency should raise prices in the Substitutes Symmetric network and lower prices in the Complements Symmetric network, while leaving the Baseline network unchanged.

Figure 10 plots the difference in prices between the transparent (public) and non-transparent (private) conditions for the Complements Symmetric, Substitutes Symmetric, and Baseline networks. Contrary to this hypothesis, price transparency lowers prices in all networks. Figure 17 in Online Appendix A shows that beliefs move in the same direction as prices.

Friends are more familiar with each other, which could lead them to have more accurate beliefs about each other and might affect their behavior in the market. Most participants believe this theory. After the experiment, I asked a subset of participants (not preregistered) if they agreed with the following statement "I am a better at predicting what price [Name of my Friend] is asking for than what a stranger is asking for." Approximately 63% answered yes (n = 144).

I test this theory by regressing a measure of belief accuracy on a dummy variable that indicates if the belief concerns a friend or a stranger, along with several control variables. Belief accuracy is quantified using the quadratic deviation of elicited beliefs from actual actions, normalized to a scale from 0 to 1.[32] The controls include the treatment and a

[30] Among these analyses, only the quantity-based analysis is pre-registered.

[31] In a literal interpretation, μ captures intrinsic altruism toward a friend. More generally, μ can be interpreted as a reduced-form measure of any channel through which friendships internalize externalities, including social sanctions ("social collateral") (e.g. Karlan et al., 2009; Leider et al., 2009). Under such mechanisms, transparency increases the effective weight placed on a friend's payoff. By contrast, intrinsic altruism need not depend on observability and therefore should not vary with transparency.

[32] This is done by dividing by the maximum possible quadratic deviation (50^2). That is the squared

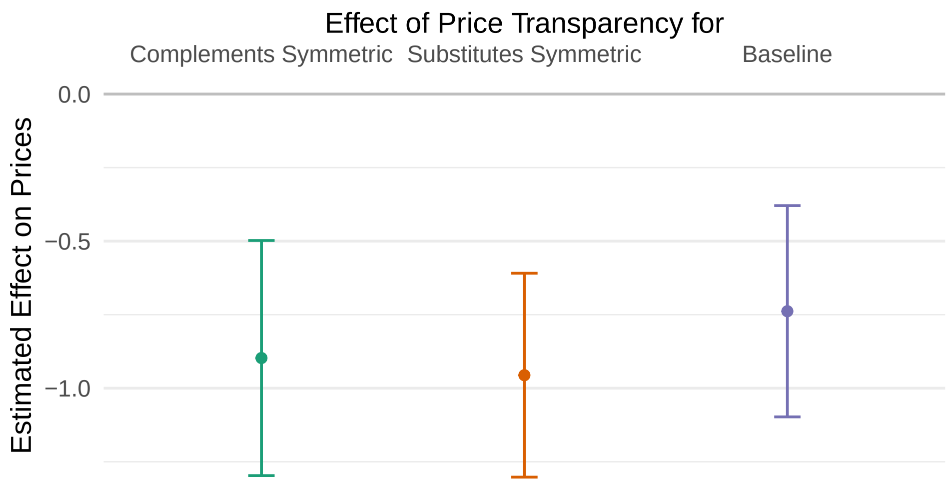


Figure 10: Estimated effects of price transparency on prices in the Complements Symmetric and Substitutes Symmetric treatments. Standard errors are clustered by friendship pair. Error bars indicate 95% confidence intervals. Each regression includes 2400 observations in 120 clusters.

dummy variable indicating whether the belief pertains to someone selling a complement or a substitute. Standard errors are clustered at the friendship-pair level for the believers.

Participants' beliefs about friends are not significantly more accurate than those about strangers. Row (1) of Table 3 reports the result of the preregistered specification. The coefficient of the friendships dummy is nonsignificant and small.

Rows (2) and (3) report exploratory (not preregistered) analyses to explore the robustness of this finding. These analyses indicate that closer friends (as measured by the standardized IOS value) are not better at predicting their friends' actions. People who stated that they had more accurate beliefs about their friends than about strangers (better beliefs dummy) do not have significantly more accurate beliefs about their friends than about strangers.

If participants know something about their friend's actions, they should adjust their choices based on that knowledge. This adjustment should lead to a correlation between friends' choices. The analysis reported in Online Appendix C does not find any evidence of such a correlation.

3.3 Structural Estimation

To gauge whether the theory matches the data in magnitude, I estimate its key parameter using a fitted structural model (this specification was not preregistered).

For the *Duopoly* experiment, average behavior in the Baseline is almost indistinguishable from the Nash equilibrium, and the strategy space is continuous. I therefore estimate

size of the strategy space/

Table 3: Regressions of belief accuracy on a friendship dummy and additional controls.

	Dependent variable:		
		$\frac{(Belief-Price)^2}{50^2}$	
	(1)	(2)	(3)
Friend	0.005	0.005	0.020*
	(0.007)	(0.007)	(0.012)
IOS Scale (standardized)		0.004	
		(0.003)	
Friend*IOS (standardized)		−0.005	
		(0.005)	
Better Beliefs			−0.003
			(0.007)
Friend*Better Beliefs			−0.021
			(0.013)
Observations	5,757	5,757	3,453
R^2	0.014	0.015	0.013

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are clustered on the friendship pair level. All regressions control for treatment dummies and a dummy that indicates if the belief is about a person selling a complement.

the single-parameter model from Section 2. Proposition 1 in Appendix A shows that, in this model, the altruism parameter is given by

$$\mu = \frac{a}{c}\left(\frac{1}{s(0)} - \frac{1}{s(\mu)}\right),$$

where $s(0)$ denotes the equilibrium strategy without friends and $s(\mu)$ the equilibrium strategy with friends.

I estimate $s(0)$ and $s(\mu)$ using the corresponding average strategies in the Baseline and Treatment groups. For each parameter configuration, I plug the empirical group means into the expression above to obtain a game-parameter-specific estimate $\hat{\mu}$, and then report the average of these estimates across configurations.[33] I estimate $\mu \approx 0.3$ with a 95% confidence interval of $[0.2, 0.4]$.[34]

As opposed to the *Duopoly* experiment, the *Network* experiment features uncertainty about the buyer's decision. In the data, this leads to prices that are uniformly below the

[33] This estimator is consistent under the maintained assumption that, within each parameter configuration, the observed average strategy converges to the corresponding equilibrium strategy in the Baseline and Treatment conditions. Because μ is a smooth function of $(s(0), s(\mu))$ on the relevant domain (with strategies bounded away from zero), the plug-in estimator inherits consistency by the continuous mapping theorem. In practice, I compute $\hat{\mu}$ separately for each parameter configuration and then average across configurations to reduce sampling noise while preserving the model-implied mapping from average behavior to μ.

[34] Standard errors are calculated using a cluster bootstrap (2,000 draws) with resampling of friendship pairs. The data include 100 clusters and denominators are non-zero in every iteration.

risk-neutral Nash benchmark—a pattern that is not central to the object of this study and is widely discussed in the auction literature as "overbidding" (John H Kagel, 1995; Kagel and Levin, 2016).[35] I capture this level shift by adding a constant "joy of winning" term α to sellers' payoffs (see, e.g., Ertaç et al., 2011).

A second feature of the *network* experiment data is that price transparency induces a uniform reduction in prices. I model this as a public-treatment penalty that increases in the chosen price, parameterized by ρ. Finally, I allow directed altruism to depend on price transparency, to capture the hypothesis that social sanctions intensify altruistic behavior when prices are observable (public) relative to when they are not (private).

Formally, letting $\boldsymbol{p} = (p_1, p_2, p_3, p_4)^\top$ denote the vector of prices, $S \in [0, 20]$ the subsidy, $O \in \{\text{public}, \text{private}\}$ the transparency condition, and $f(1)$ player 1's friend (if any), player 1's utility and expected profit are given by

$$u_1(\boldsymbol{p}; S, O, \alpha, \rho, \mu(O)) = \pi_1(\boldsymbol{p}; S, \alpha) + \mu(O)\, \pi_{f(1)}(\boldsymbol{p}; S, \alpha) - \mathbb{1}\{O = \text{public}\}\, \rho\, p_1, \tag{4}$$

$$\pi_1(\boldsymbol{p}; S, \alpha) = Pr_\ell(\boldsymbol{p})\, \big(\alpha + S + p_1\big), \tag{5}$$

where $Pr_\ell(\boldsymbol{p})$ is the probability that player 1 makes a sale at price p_1 given the price vector $\boldsymbol{p}$. The utility of players 1 to 4 is analogous.

Since the strategy space is discrete, I estimate the model using quantal response equilibrium (QRE), which extends standard discrete-choice (random-utility) models to strategic settings (McKelvey and Palfrey, 1995). In QRE, players choose higher-utility actions with higher probability, allowing for decision error or other unmodeled factors. The parameter λ governs the sensitivity of choices to payoffs: Larger values of λ imply less noise and choices closer to best responses. Appendix H provides estimation details.

Table 4 lists the estimated parameters with 95% confidence intervals. Despite being from different samples and games the parameter estimates for altruism among friends are virtually identical for the *Network* (0.277) and *Duopoly* (0.3) experiments. The remaining estimates confirm that price transparency does not increase directed altruism behavior, but instead uniformly lowers prices. This is equivalent to lowering the marginal gain of price increases by 4 percentage points (see estimate for ρ).

[35] The sign is reversed here since this paper studies a reverse auction, whereas the literature mostly studies regular auctions.

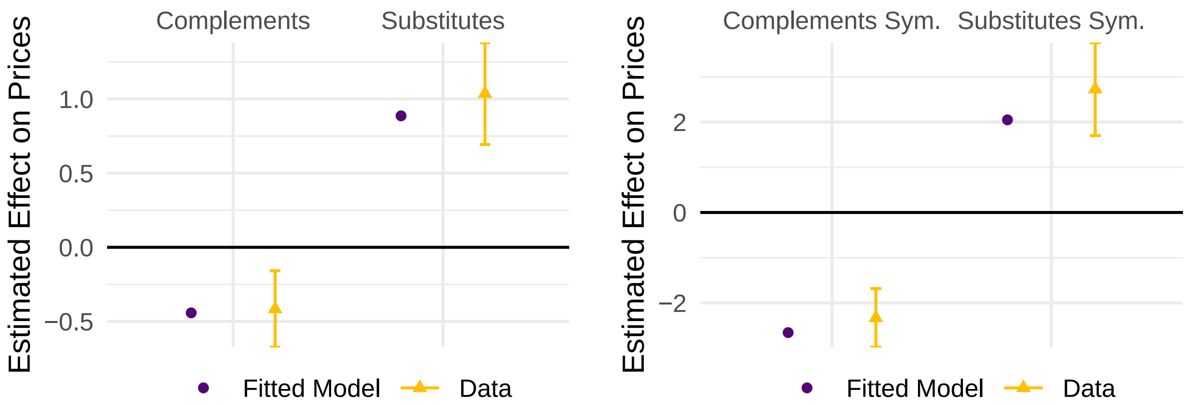
Table 4: Parameter estimates for the QRE-Directed-Altruism model.

Parameter	Explanation	Estimate	95% CI
Directed Altruism			
$\mu(private)$	private	0.277***	(0.193, 0.361)
$\mu(public) - \mu(private)$	increase public	0.009	(−0.057, 0.074)
ρ	social image concerns	0.037***	(0.013, 0.060)
α	constant	24.600***	(20.60, 28.60)
λ	QRE-parameter	0.250***	(0.189, 0.312)

Notes: *p<0.1; **p<0.05; ***p<0.01; standard errors are clusterd on the friendship pair level.

Introducing altruism among strangers has minimal impact on the structural estimates. Online Appendix D demonstrates that altruism among strangers neither shifts predicted behavior nor structural estimates.

Finally compare the treatment effects generated from the fitted model to the effects estimated using the raw data. This comparison is shown in Figure 11. The upper panel shows data and model for the *Duopoly* experiment and the lower figure displays the corresponding data for the network experiment. The empirical estimates are shown in yellow and compared to the purple dots that show the estimates from the fitted model. For both experiments the fitted model and the raw data are similar and not significantly different.



(a) *Duopoly* Game

(b) *Network* Game

Figure 11: This figure shows the estimated treatment effects predicted by the fitted structural model and the reduced-form treatment effect estimates, along with 95% confidence intervals calculated using standard errors clustered at the friendship-pair level. The estimated treatment effects are drawn from the main analysis, which is reported in Figure 7.

4 Discussion

I do not find evidence for equilibrium spillovers of friendships between two people on other people's strategies (Prediction 2). While QRE decision errors could explain some of the lack of spillovers, biased beliefs are the most likely cause: Participants under-react in their beliefs to changes in the social network when those changes don't impact them directly, which may, in turn, lead to an under-reaction in their strategic decisions.

The data and the estimated structural model suggest that price transparency does not increase cooperativeness between friends but reduces prices uniformly. This price reduction could be due to increased social image concerns: Participants care how they appear to their friends and strangers and reduce their prices because high prices seem greedy. This theory aligns with the participants' free text answers to an open question about the topic (See Online Appendix B).

The effect of friendship on market outcomes is robust to the mode of competition. In line with Predictions 3 and 4, when I compare Bertrand and Cournot environments the friendship effect does not depend on whether strategies are labeled as prices or quantities. At the same time, moving from Bertrand to Cournot necessarily changes the underlying primitives. Under substitutes, this implies that, measured in the strategic variable—friends appear to collude more in Bertrand than in Cournot, while under complements the pattern is reversed, as expected. These differences are not robust: They become insignificant when outcomes are evaluated in terms of all prices or all quantities, and they disappear entirely when I use the standard normalized collusion index of Engel (2006).

5 Conclusion

While the preceding section highlights the boundaries of directed altruism theory, the theory performs well overall. Except for the lack of equilibrium spillovers in asymmetric networks, Prediction 1 is confirmed in both experiments: Friendships among complements decrease prices and increase efficiency, while friendships among substitutes raise prices and reduce efficiency.

Moreover, I find no evidence in support of the most plausible alternative mechanism—greater belief accuracy among friends. Finally, a simple structural model of directed altruism fits the data well and matches behavior across different social relationships (among substitutes and complements) and across both games (*Duopoly* and *Network*) using a single common altruism parameter. This consistency strengthens the case for directed altruism as a workhorse framework for analyzing how social relationships affect market outcomes, and the experimental results recommend it as the primary candidate for modeling the effect of social relationships on prices.

A Proofs Duopoly Game

Definition 1 (Duopoly game). Fix parameters $a \in \mathbb{R}_{>0}$, $b \in \mathbb{R}_{<0}$, $c \in \mathbb{R}$, and $\mu \in [0,1]$. Each player $i \in \{1,2\}$ simultaneously chooses an action $s_i \in \mathbb{R}_{\geq 0}$. Payoffs are

$$\begin{aligned} U_1(s_1, s_2) &= s_1\big(a + bs_1 + cs_2\big) + \mu\, s_2\big(a + bs_2 + cs_1\big), \\ U_2(s_1, s_2) &= s_2\big(a + bs_2 + cs_1\big) + \mu\, s_1\big(a + bs_1 + cs_2\big). \end{aligned}$$

Proposition 1 (Equilibrium and identification)**.** *Consider a duopoly game and assume* $|2b| > (1+\mu)|c|$.

(1) Strategies are strategic complements if $c > 0$ *and strategic substitutes if* $c < 0$.

(2) There is a unique symmetric Nash equilibrium $s_1 = s_2 = s(\mu)$ *given by*

$$s(\mu) = -\frac{a}{2b + (1+\mu)c}.$$

Moreover, $s(\mu)$ *is increasing in* μ *if and only if* $c > 0$.

(3) If $c \neq 0$, *then* μ *is identified by*

$$\mu = \frac{a}{c}\left(\frac{1}{s(0)} - \frac{1}{s(\mu)}\right).$$

Proof of Proposition 1. Player 1 solves

$$\max_{s_1 \geq 0} \quad s_1\big(a + bs_1 + cs_2\big) \; + \; \mu\, s_2\big(a + bs_2 + cs_1\big). \tag{6}$$

The first-order condition (for an interior optimum) is

$$\begin{aligned} 0 &= \frac{\partial}{\partial s_1}\Big[s_1(a + bs_1 + cs_2) + \mu s_2(a + bs_2 + cs_1)\Big] \\ &= a + 2bs_1 + (1+\mu)cs_2. \end{aligned} \tag{7}$$

The second-order condition is $2b < 0$, which holds by assumption.

Solving the FOC for s_1 and imposing $s_1 \geq 0$ yields the reaction function

$$s_1(s_2) = \max\left\{-\frac{a + (1+\mu)c\, s_2}{2b},\, 0\right\},$$

and symmetrically for player 2. On the interior branch, its slope is $-\frac{(1+\mu)c}{2b}$, which has the sign of c because $b < 0$. This gives part (1).

I establish uniqueness by showing that the composition of best responses is a contraction. Let

$$BR_i(x) = \max\{r + mx, 0\}, \qquad r := -\frac{a}{2b}, \qquad m := -\frac{(1+\mu)c}{2b},$$

for $i = 1, 2$ (the two best responses are symmetric), and define

$$f := BR_1 \circ BR_2.$$

Fix two points s' and s''. Since $x \mapsto \max\{x, 0\}$ is the metric projection onto $[0, \infty)$ (equivalently, $\mathbb{R}_{\geq 0}$), it is non-expansive. Hence each BR_i is $|m|$-Lipschitz, and therefore

$$|f(s') - f(s'')| = |BR_1(BR_2(s')) - BR_1(BR_2(s''))| \leq |m|^2 \, |s' - s''|. \tag{8}$$

Thus f is a contraction if $|m|^2 < 1$, equivalently if

$$|m| = \left| \frac{(1+\mu)c}{2b} \right| < 1,$$

which is equivalent to the assumption $|2b| > (1+\mu)|c|$.

For the symmetric equilibrium, set $s_1 = s_2 = s$. Then

$$0 = a + \big(2b + (1+\mu)c\big)s \quad \Rightarrow \quad s(\mu) = -\frac{a}{2b + (1+\mu)c} > 0,$$

which proves part (2). Differentiating shows $\partial s(\mu)/\partial \mu$ has the sign of c.

For part (3), note that $s(0) = -a/(2b + c)$ and $s(\mu) = -a/(2b + (1+\mu)c)$. Hence

$$\frac{a}{c}\left(\frac{1}{s(0)} - \frac{1}{s(\mu)}\right) = \frac{a}{c}\left(\frac{2b + c}{-a} - \frac{2b + (1+\mu)c}{-a}\right) = \mu.$$

□

Definition 2 (Cournot game). Consider a duopoly game in which strategies are interpreted as quantities (set $q_1 := s_1$ and $q_2 := s_2$). Define inverse demand by

$$p_1(q_1, q_2) := a + bq_1 + cq_2,$$
$$p_2(q_1, q_2) := a + bq_2 + cq_1.$$

Definition 3 (Bertrand game). Consider a duopoly game in which strategies are interpreted as prices (set $p_1 := s_1$ and $p_2 := s_2$). Define demand by

$$q_1(p_1, p_2) := a + bp_1 + cp_2,$$
$$q_2(p_1, p_2) := a + bp_2 + cp_1.$$

Definition 4 (Substitutes and complements). Fix $\alpha, \beta, \gamma > 0$ such that $\beta > \gamma$, and define

$$\delta := \beta^2 - \gamma^2.$$

A **Cournot–substitutes** game is a Cournot game with parameters

$$a = \alpha, \qquad b = -\beta, \qquad c = -\gamma.$$

Let $q^{\mathrm{C}}_{\mathrm{sub}}(\mu)$ and $p^{\mathrm{C}}_{\mathrm{sub}}(\mu)$ denote the symmetric equilibrium quantity (per firm) and price.

A **Cournot–complements** game is a Cournot game with parameters

$$a = \frac{\alpha(\beta - \gamma)}{\delta}, \qquad b = -\frac{\beta}{\delta}, \qquad c = \frac{\gamma}{\delta}.$$

Let $q^{\mathrm{C}}_{\mathrm{comp}}(\mu)$ and $p^{\mathrm{C}}_{\mathrm{comp}}(\mu)$ denote the symmetric equilibrium quantity (per firm) and price.

A **Bertrand–complements** game is a Bertrand game with parameters

$$a = \alpha, \qquad b = -\beta, \qquad c = -\gamma.$$

Let $q^{\mathrm{B}}_{\mathrm{comp}}(\mu)$ and $p^{\mathrm{B}}_{\mathrm{comp}}(\mu)$ denote the symmetric equilibrium quantity and price.

A **Bertrand–substitutes** game is a Bertrand game with parameters

$$a = \frac{\alpha(\beta - \gamma)}{\delta}, \qquad b = -\frac{\beta}{\delta}, \qquad c = \frac{\gamma}{\delta}.$$

Let $q^{\mathrm{B}}_{\mathrm{sub}}(\mu)$ and $p^{\mathrm{B}}_{\mathrm{sub}}(\mu)$ denote the symmetric equilibrium quantity and price.

Corollary 1 (Cournot–Bertrand equivalences). The Cournot–substitutes game and the Bertrand–complements game are games of *strategic substitutes.* Likewise, the Cournot–complements game and the Bertrand–substitutes game are games of *strategic complements.*

Moreover, for games of **strategic substitutes**,

$$q^{\mathrm{C}}_{\mathrm{sub}}(\mu) = p^{\mathrm{B}}_{\mathrm{comp}}(\mu), \tag{9}$$
$$p^{\mathrm{C}}_{\mathrm{sub}}(\mu) = q^{\mathrm{B}}_{\mathrm{comp}}(\mu), \tag{10}$$

and for games of **strategic complements**,

$$q^{\mathrm{C}}_{\mathrm{comp}}(\mu) = p^{\mathrm{B}}_{\mathrm{sub}}(\mu), \tag{11}$$
$$p^{\mathrm{C}}_{\mathrm{comp}}(\mu) = q^{\mathrm{B}}_{\mathrm{sub}}(\mu). \tag{12}$$

Proof of Corollary 1. The first claim follows from part (1) of Proposition 1. Equations (9) and (11) follow because the variables on the left- and right-hand sides are symmetric equilibrium *strategies* in strategically equivalent games. Equations (10) and (12) then follow because the corresponding price and quantity objects are identical transformations of those equilibrium strategies in strategically equivalent games. □

Proposition 2 (Effect of friendship on cooperation)**.** *Fix $\alpha, \beta, \gamma > 0$ with $\beta > \gamma$ and consider an increase in μ from 0 to $\mu' \in (0, 1]$.*

*For **substitutes**, prices increase and quantities decrease:*

$$p^{\mathrm{B}}_{\mathrm{sub}}(\mu') - p^{\mathrm{B}}_{\mathrm{sub}}(0) > 0, \qquad p^{\mathrm{C}}_{\mathrm{sub}}(\mu') - p^{\mathrm{C}}_{\mathrm{sub}}(0) > 0, \tag{13}$$

$$q^{\mathrm{B}}_{\mathrm{sub}}(\mu') - q^{\mathrm{B}}_{\mathrm{sub}}(0) < 0, \qquad q^{\mathrm{C}}_{\mathrm{sub}}(\mu') - q^{\mathrm{C}}_{\mathrm{sub}}(0) < 0. \tag{14}$$

*For **complements**, prices decrease and quantities increase:*

$$p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0) < 0, \qquad p^{\mathrm{C}}_{\mathrm{comp}}(\mu') - p^{\mathrm{C}}_{\mathrm{comp}}(0) < 0, \tag{15}$$

$$q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0) > 0, \qquad q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0) > 0. \tag{16}$$

There exist thresholds $\underline{\mu}, \overline{\mu} \in \mathbb{R}$ such that:

(1) If $\mu' > \underline{\mu}$, then the magnitude of the friendship effect on strategies *is larger in games of strategic complements (Cournot–complements and Bertrand–substitutes) than in games of strategic substitutes (Cournot–substitutes and Bertrand–complements). Equivalently,*

$$\begin{aligned} \left|q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0)\right| &= \left|p^{\mathrm{B}}_{\mathrm{sub}}(\mu') - p^{\mathrm{B}}_{\mathrm{sub}}(0)\right| \\ &> \left|q^{\mathrm{C}}_{\mathrm{sub}}(\mu') - q^{\mathrm{C}}_{\mathrm{sub}}(0)\right| = \left|p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0)\right|. \end{aligned} \tag{17}$$

*(2) If $\mu' > \overline{\mu}$, then in terms of observable outcomes (prices and quantities), the friendship effect is stronger in the strategically complementary specification. In particular, for **substitutes**,*

$$p^{\mathrm{B}}_{\mathrm{sub}}(\mu') - p^{\mathrm{B}}_{\mathrm{sub}}(0) > p^{\mathrm{C}}_{\mathrm{sub}}(\mu') - p^{\mathrm{C}}_{\mathrm{sub}}(0) > 0, \tag{18}$$

$$q^{\mathrm{B}}_{\mathrm{sub}}(\mu') - q^{\mathrm{B}}_{\mathrm{sub}}(0) < q^{\mathrm{C}}_{\mathrm{sub}}(\mu') - q^{\mathrm{C}}_{\mathrm{sub}}(0) < 0, \tag{19}$$

*and for **complements**,*

$$p^{\mathrm{C}}_{\mathrm{comp}}(\mu') - p^{\mathrm{C}}_{\mathrm{comp}}(0) < p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0) < 0, \tag{20}$$

$$q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0) > q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0) > 0. \tag{21}$$

Moreover, if $\beta + \gamma > 1$, then $\overline{\mu} > \underline{\mu}$.

We break up the proof of Proposition 2 into two lemmas. Lemma 1 uses Corollary 1 to reduce the collection of inequalities in statement (2) to a single inequality. Lemma 2 then derives the corresponding thresholds and compares the magnitudes of the friendship effects.

Lemma 1. *The inequalities in statement (2) of Proposition 2 hold if and only if*

$$q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0) > q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0). \tag{22}$$

Proof of Lemma 1. We use Corollary 1 to rewrite the four inequalities in statement (2).

By (10) we have

$$p^{\mathrm{C}}_{\mathrm{sub}}(\mu) = q^{\mathrm{B}}_{\mathrm{comp}}(\mu),$$

and by (11) we have

$$p^{\mathrm{B}}_{\mathrm{sub}}(\mu) = q^{\mathrm{C}}_{\mathrm{comp}}(\mu).$$

Substituting into

$$p^{\mathrm{B}}_{\mathrm{sub}}(\mu') - p^{\mathrm{B}}_{\mathrm{sub}}(0) > p^{\mathrm{C}}_{\mathrm{sub}}(\mu') - p^{\mathrm{C}}_{\mathrm{sub}}(0)$$

yields (22).

Next, by (9) we have

$$q^{\mathrm{C}}_{\mathrm{sub}}(\mu) = p^{\mathrm{B}}_{\mathrm{comp}}(\mu),$$

and by (12) we have

$$q^{\mathrm{B}}_{\mathrm{sub}}(\mu) = p^{\mathrm{C}}_{\mathrm{comp}}(\mu).$$

Substituting into

$$q^{\mathrm{B}}_{\mathrm{sub}}(\mu') - q^{\mathrm{B}}_{\mathrm{sub}}(0) < q^{\mathrm{C}}_{\mathrm{sub}}(\mu') - q^{\mathrm{C}}_{\mathrm{sub}}(0)$$

yields

$$p^{\mathrm{C}}_{\mathrm{comp}}(\mu') - p^{\mathrm{C}}_{\mathrm{comp}}(0) < p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0). \tag{23}$$

We now show (23) is equivalent to (22). In a Cournot game,

$$p = a + (b + c)q \quad \text{in a symmetric equilibrium.}$$

For Cournot–complements,

$$a = \frac{\alpha(\beta - \gamma)}{\delta}, \quad b = -\frac{\beta}{\delta}, \quad c = \frac{\gamma}{\delta},$$

so $b + c = -(\beta - \gamma)/\delta$ and

$$p^{\mathrm{C}}_{\mathrm{comp}}(\mu) = \frac{\alpha - q^{\mathrm{C}}_{\mathrm{comp}}(\mu)}{\beta + \gamma}. \tag{24}$$

In a Bertrand game,

$$q = a + (b+c)p \quad \text{in a symmetric equilibrium.}$$

For Bertrand–complements, $a = \alpha$, $b = -\beta$, $c = -\gamma$, so $b + c = -(\beta + \gamma)$ and

$$p^{\mathrm{B}}_{\mathrm{comp}}(\mu) = \frac{\alpha - q^{\mathrm{B}}_{\mathrm{comp}}(\mu)}{\beta + \gamma}. \tag{25}$$

Using (24) and (25),

$$p^{\mathrm{C}}_{\mathrm{comp}}(\mu') - p^{\mathrm{C}}_{\mathrm{comp}}(0) = -\frac{1}{\beta+\gamma}\Big(q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0)\Big), \tag{26}$$
$$p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0) = -\frac{1}{\beta+\gamma}\Big(q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0)\Big). \tag{27}$$

Since $\beta + \gamma > 0$, inequality (23) is equivalent to (22). $\square$

Lemma 2. *Fix $\mu' \in (0, 1]$. The following statements hold:*

(1) The strategy-magnitude inequality

$$\big|q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0)\big| > \big|p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0)\big| \tag{28}$$

holds if and only if

$$\beta - \gamma > \frac{(2\beta-\gamma)\big(2\beta-(1+\mu')\gamma\big)}{(2\beta+\gamma)\big(2\beta+(1+\mu')\gamma\big)}. \tag{29}$$

(2) Inequality (22) holds if and only if

$$\mu' > \frac{\gamma^2}{2\beta^2-\gamma^2}.$$

(3) If $\beta + \gamma > 1$, then (22) implies (28).

Proof of Lemma 2. We check that $|2b| > (1 + \mu)|c|$ holds for all $\mu \in [0, 1]$ in the two games used below. Since $\mu \in [0, 1]$, we have $1 + \mu \le 2$. Hence $|b| > |c|$ implies

$$|2b| = 2|b| > 2|c| \ge (1+\mu)|c|,$$

so it suffices to check $|b| > |c|$. For Cournot–complements,

$$b = -\frac{\beta}{\delta}, \quad c = \frac{\gamma}{\delta},$$

so $|b| > |c|$ is implied by $\beta > \gamma$. For Bertrand–complements, $b = -\beta$, $c = -\gamma$, so $|b| > |c|$ is implied by $\beta > \gamma$.

From Proposition 1,

$$s(\mu') - s(0) = -\frac{a}{2b + (1+\mu')c} + \frac{a}{2b+c} = \frac{ac\mu'}{(2b+(1+\mu')c)(2b+c)}. \tag{30}$$

In Cournot–complements, $s = q^{\mathrm{C}}_{\mathrm{comp}}$. Substituting the Cournot–complements parameters into (30) yields

$$q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0) = \frac{\alpha(\beta-\gamma)\gamma\,\mu'}{\big(2\beta - (1+\mu')\gamma\big)\big(2\beta-\gamma\big)}. \tag{31}$$

In Bertrand–complements, $s = p^{\mathrm{B}}_{\mathrm{comp}}$. Substituting into (30) gives

$$p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0) = -\frac{\alpha\gamma\,\mu'}{\big(2\beta + (1+\mu')\gamma\big)\big(2\beta+\gamma\big)}. \tag{32}$$

Taking absolute values in (31) and (32) and canceling the common factor $\alpha\gamma\mu' > 0$, (28) is equivalent to

$$\frac{\beta-\gamma}{(2\beta-\gamma)\big(2\beta-(1+\mu')\gamma\big)} > \frac{1}{(2\beta+\gamma)\big(2\beta+(1+\mu')\gamma\big)},$$

which rearranges to (29). This proves (1).

In the Bertrand–complements game, symmetric equilibrium quantities satisfy

$$q^{\mathrm{B}}_{\mathrm{comp}}(\mu) = \alpha - (\beta+\gamma)p^{\mathrm{B}}_{\mathrm{comp}}(\mu),$$

so

$$q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0) = -(\beta+\gamma)\big(p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0)\big).$$

Using (32), we obtain

$$q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0) = \frac{(\beta+\gamma)\alpha\gamma\,\mu'}{\big(2\beta + (1+\mu')\gamma\big)\big(2\beta+\gamma\big)}.$$

Substituting this and (31) into (22) and canceling $\alpha\gamma\mu' > 0$ yields

$$\frac{\beta-\gamma}{(2\beta-\gamma)\big(2\beta-(1+\mu')\gamma\big)} > \frac{\beta+\gamma}{(2\beta+\gamma)\big(2\beta+(1+\mu')\gamma\big)}. \tag{33}$$

All denominators are positive under $\beta > \gamma$ and $\mu' \in (0,1]$, so cross-multiplication and simplification give

$$2\gamma\big((2\beta^2-\gamma^2)\mu' - \gamma^2\big) > 0,$$

which is equivalent to $\mu' > \gamma^2/(2\beta^2-\gamma^2)$. This proves (2).

From the identity

$$\left|p^{\mathrm{B}}_{\mathrm{comp}}(\mu') - p^{\mathrm{B}}_{\mathrm{comp}}(0)\right| = \frac{1}{\beta+\gamma}\left|q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0)\right|,$$

inequality (28) is equivalent to

$$(\beta+\gamma)\left|q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0)\right| > \left|q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0)\right|.$$

If (22) holds, then multiplying its left-hand side by $\beta+\gamma > 1$ preserves a strict inequality and yields (28). This proves (3). $\square$

Proof of Proposition 2. Fix $\alpha, \beta, \gamma > 0$ with $\beta > \gamma$ and let $\mu' \in (0, 1]$.

Step 1: Signs (prices vs. quantities). Proposition 1(2) implies that the derivative of s with respect to μ has the same sign as c. This directly proves the desired result.

In Cournot games, $s = q$ and (in symmetry) $p = a + (b + c)q$. In Bertrand games, $s = p$ and (in symmetry) $q = a + (b + c)p$. In all four parameterizations in Definition 4, we have $b + c < 0$, so prices and quantities move in opposite directions.

Checking each case:

- Cournot–substitutes: $c = -\gamma < 0$, so q falls and p rises.
- Bertrand–substitutes: $c = \gamma/\delta > 0$, so p rises and q falls.
- Cournot–complements: $c = \gamma/\delta > 0$, so q rises and p falls.
- Bertrand–complements: $c = -\gamma < 0$, so p falls and q rises.

This proves the sign inequalities.

Step 2: Strategy-space threshold $\underline{\mu}$. Statement (1) is equivalent to (28). By Lemma 2(1), (28) holds if and only if (29) holds. Since the right-hand side of (29) is strictly decreasing in μ', the set of $\mu' \in (0, 1]$ satisfying (29) is an interval of the form $(\underline{\mu}, 1]$ for some threshold $\underline{\mu} \in \mathbb{R}$.

Step 3: Outcome-space threshold $\overline{\mu}$. By Lemma 1, statement (2) is equivalent to (22). By Lemma 2(2), (22) holds if and only if

$$\mu' > \frac{\gamma^2}{2\beta^2 - \gamma^2}.$$

Define

$$\overline{\mu} := \frac{\gamma^2}{2\beta^2 - \gamma^2}.$$

Then statement (2) holds for all $\mu' > \overline{\mu}$.

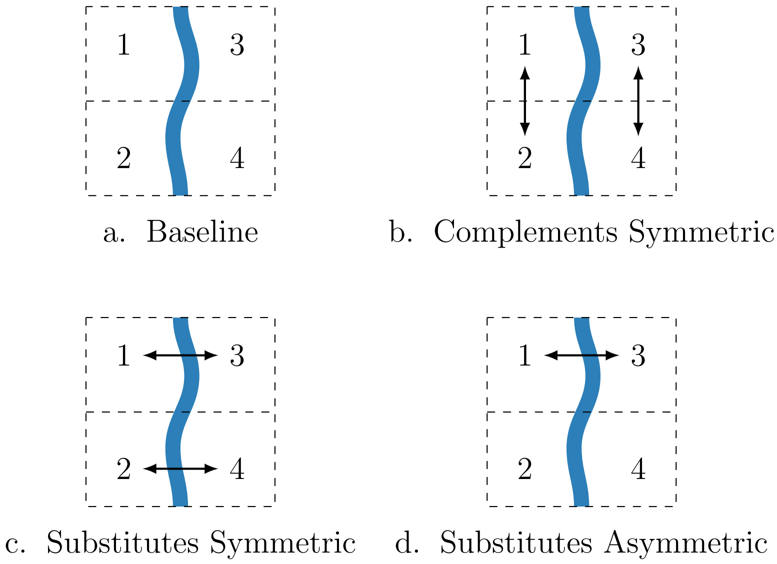


Figure 12: The experimental market with different social networks. The different plots are separated by the river (in blue) and the dotted line. Bidirectional arrows indicate friendships.

Step 4: Ordering when $\beta + \gamma > 1$. If $\beta + \gamma > 1$, Lemma 2, part (3) implies $\overline{\mu} \geq \underline{\mu}$.

Moreover, at $\mu' = \overline{\mu}$ inequality (22) holds with equality, while (28) is equivalent to

$$(\beta + \gamma) \left| q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0) \right| > \left| q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0) \right| .$$

Thus, when $\mu' = \overline{\mu}$ we have $|q^{\mathrm{C}}_{\mathrm{comp}}(\mu') - q^{\mathrm{C}}_{\mathrm{comp}}(0)| = |q^{\mathrm{B}}_{\mathrm{comp}}(\mu') - q^{\mathrm{B}}_{\mathrm{comp}}(0)|$, and since $\beta + \gamma > 1$ this yields (28) strictly. Therefore $\underline{\mu} < \overline{\mu}$. $\square$

B Proofs Network Game

I compare different social networks to a Baseline social network without social relationships. These networks are depicted in Figure 12. The subcaptions indicate the social network treatment of player 1. The different plots are separated by the river (in blue) and the dotted line. Bidirectional arrows indicate friendships.

Social networks, combined with market institutions, give rise to several games. I analyze the symmetric equilibria, in which players with the same utility functions adopt the same strategy. Lemma 3 demonstrates that all games with symmetric networks possess unique symmetric Nash equilibria. These symmetric equilibria are interior and in pure strategies.

Lemma 3. *The games generated by the Substitute's Symmetric, Baseline, and Complement Symmetric networks have a symmetric equilibrium. This symmetric equilibrium is the only symmetric equilibrium, interior and in pure strategies. Best responses are interior, unique and deterministic everywhere.*

Proposition 3. *The symmetric equilibrium price in the Substitutes Symmetric network (p_s^*) exceeds that in the Baseline network (p_b^*), which exceeds that in the Complement Symmetric network (p_c^*), $p_s^* > p_b^* > p_c^*$.*

For ease of notation, I write all proofs for a uniform value distribution from 0 to 1 and prices from 0 to 0.5.

Proof of Lemma 3. Recall that $p_\ell = p_1 + p_2$ and $p_r = p_3 + p_4$. The probability that the buyer buys on the left-side is

$$\Pr_\ell(p_1, p_2, p_3, p_4) = \int_0^1 \int_0^1 \mathbb{1}(\theta_\ell - p_\ell > \theta_r - p_r)\mathbb{1}(\theta_\ell - p_\ell > 0) f(\theta_r) f(\theta_\ell) d\theta_\ell d\theta_r \tag{34}$$

$$= \begin{cases} (1 - p_\ell) - 0.5(1 - p_r)^2 & \text{if } p_\ell \leq p_r \\ (1 - p_\ell) \cdot p_r + 0.5(1 - p_\ell)^2 & if\ p_r < p_\ell \end{cases}. \tag{35}$$

I start by characterizing the symmetric equilibrium of the Substitutes Symmetric network.

Player 1 solves

$$\max_{p_1 \in [0,0.5]} \Pr_\ell(p_1, p_2, p_3, p_4) \cdot (p_1 + S) + \mu \cdot \Pr_r(p_1, p_2, p_3, p_4) \cdot (p_3 + S)$$

The first-order condition is:

$$\frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1} \cdot (p_1 + S) + \Pr_\ell(p_1, p_2, p_3, p_4) + \mu \frac{\partial \Pr_r(p_1, p_2, p_3, p_4)}{\partial p_1} \cdot (p_3 + S) = 0$$

and the second-order condition is:

$$\frac{\partial^2 \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1^2} \cdot (p_1 + S) + 2 \cdot \frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1} + \\ + \mu \cdot \frac{\partial^2 \Pr_r(p_1, p_2, p_3, p_4)}{\partial p_1^2} \cdot (p_3 + S) < 0$$

By plugging in the derivatives of Equation 35 into the second-order condition, we obtain

$$-2 < 0, \text{ if } p_\ell \leq p_r$$

and

$$-(p_1 + S) - 2(1 + p_r - p_\ell) - \mu(p_3 + S) \text{ if } p_r < p_\ell,$$

which is true and implies that player 1's utility function is strictly concave in p_1. Since the second-order conditions are linear in the other player's prices, they also hold when the other player plays a mixed strategy. Therefore, all players' utility functions are always strictly concave in price, and their best response is deterministic and solves the first-order condition.

Any symmetric equilibrium strategy p_s satisfies the first-order condition:

$$g(p_s, \mu) := \frac{\partial Pr_\ell(p_s, p_s, p_s, p_s)}{\partial p_1}(p_s + S) + \Pr_\ell(p_s, p_s, p_s, p_s) + \tag{36}$$

$$+\mu \frac{\partial \Pr_r(p_s, p_s, p_s, p_s)}{\partial p_1}(p_s + S) = 0 \tag{37}$$

$$\Leftrightarrow g(p_s, \mu) = -(p_s + S) + (1 - 2p_s) - 0.5(1 - 2p_s)^2 + \mu(1 - 2p_s)(p_s + S) = 0 \tag{38}$$

.

I use the intermediate value theorem to show that this equation has a solution within the strategy space. The function g is continuous because it is a composition of continuous functions. I calculate that $g(0, \mu) = (-1 + \mu)S + 0.5$ and $g(0.5, \mu) = -(1 + S)$. The first expression is larger than 0 if $(-1+\mu)S+0.5 > 0 \Leftrightarrow 0.5 > (1-\mu)\cdot S$. This is true because $S \leq 0.2 \wedge \mu \leq 1 \rightarrow 0.5 > (1 + \mu) \cdot S$. The second ($g(0.5, \mu)$) is always smaller than zero. The function g has only one critical point at $p_s = \frac{\mu-2\mu S-1}{4(\mu+1)} \leq \frac{\mu-1}{4(\mu+1)} \leq 0$. Therefore, g is decreasing in the strategy space. Consequently, the first-order condition has a unique interior solution by the intermediate value theorem. Furthermore, this solution is the symmetric equilibrium price $0 < p_s < 0.5$.

Now, I characterize the symmetric equilibrium of the Complements Symmetric network. Player 1 solves

$$\max_{p_1} \Pr_\ell(p_1, p_2, p_3, p_4) \cdot (p_1 + S) + \mu \cdot \Pr_\ell(p_1, p_2, p_3, p_4) \cdot (p_2 + S)$$

The first-order condition of player 1 is:

$$\frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1}(p_1 + S) + \Pr_\ell(p_1, p_2, p_3, p_4) + \mu \frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1} \cdot (p_2 + S) = 0$$

and the second-order condition is:

$$\frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial^2 p_1}(p_1 + S) + 2\frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial p_1} + \mu \frac{\partial \Pr_\ell(p_1, p_2, p_3, p_4)}{\partial^2 p_1} \cdot (p_2 + S) < 0$$

By plugging in the derivatives of Equation 35 into the second-order condition, we obtain

$$-2 < 0, \text{ if } p_\ell \leq p_r,$$

which is true. For $p_r < p_\ell$, we obtain

$$(p_1 + S) - 2(1 + p_r - p_\ell) - \mu(p_3 + S) + p_\ell - p_r = p_1 - \mu p_3 + (1 - \mu S) - 2,$$

which is increasing in p_1, p_2 and S and decreasing in p_3, p_4 and μ. Therefore, if we use $S < 0.2$, $p_i \in [0, 0.5]$ and $\mu > 0$, we can bound it above by $-0.3 < 0$. Taken together, these conditions imply that player 1's utility function is strictly concave in p_1. Since the first-order conditions are linear in the other player's prices, they also hold when the other player is playing a mixed strategy. Therefore, all players' utility functions are always strictly concave in their own price p_i, and their best response solves the first-order condition and is deterministic.

Any symmetric equilibrium strategy p_s satisfies the first-order condition:

$$i(p_c, \mu) := \frac{\partial \Pr_\ell(p_c, p_c, p_c, p_c)}{\partial p_1}(p_c + S) + \tag{39}$$

$$+ \Pr_\ell(p_c, p_c, p_c, p_c) + \mu \frac{\partial \Pr_\ell(p_c, p_c, p_c, p_c)}{\partial p_1}(p_c + S) = 0 \tag{40}$$

$$\Leftrightarrow i(p_c, \mu) = (1 - 2p_c) - 0.5(1 - 2p_c)^2 - (1 + \mu)(p_c + S) = 0. \tag{41}$$

I use the intermediate value theorem to show that this equation has a solution. The function i is continuous because it is a composition of continuous functions. I calculate that $i(0, \mu) = 0.5 - (1 + \mu)S$ and $i(0.5, \mu) = -(1 + \mu)(1 + S)$. The first expression is larger than 0 if $0.5 - (1 + \mu)S > 0 \Leftrightarrow 0.5 > (1 + \mu) \cdot S$, which is true by assumption. The second ($i(0.5, \mu)$) is always larger than zero. Consequently, the first-order condition has an interior solution by the intermediate value theorem. Checking ($\frac{\partial i(p_c, \mu)}{\partial p_c} = -3 - \mu - p_c < 0$ shows that i is strictly decreasing and this interior solution is unique. Therefore, the Complements Symmetric game has a unique symmetric equilibrium price $0 < p_c < 0.5$.

Since both networks nest the Baseline network, for $\mu = 0$, these results also hold for the Baseline network. □

Proof of Proposition 3. In all three symmetric networks, the equilibrium is on the interior of the price space, and the objective function is concave. Therefore, symmetric equilibrium prices solve the first-order conditions:

$$\frac{\partial \Pr_\ell(p_s, p_s, p_s, p_s)}{\partial p_1}(p_s + S) + \Pr_\ell(p_s, p_s, p_s, p_s) + \mu \frac{\partial \Pr_r(p_s, p_s, p_s, p_s)}{\partial p_1}(p_s + S) = 0 \tag{42}$$

$$\frac{\partial \Pr_\ell(p_c, p_c, p_c, p_c)}{\partial p_1}(p_c + S) + \Pr_\ell(p_c, p_c, p_c, p_c) + \mu \frac{\partial \Pr_\ell(p_c, p_c, p_c, p_c)}{\partial p_1}(p_c + S) = 0 \tag{43}$$

$$\frac{\partial \Pr_\ell(p_b, p_b, p_b, p_b)}{\partial p_1}(p_b + S) + \Pr_\ell(p_b, p_b, p_b, p_b) = 0. \tag{44}$$

Define the marginal private gain from higher prices in the symmetric equilibrium as:

$$h(p) = \frac{\partial \Pr_\ell(p, p, p, p)}{\partial p_1}(p + S) + \Pr_\ell(p, p, p, p).$$

This expression ($h(p)$) falls in p because $\frac{\partial \Pr_\ell(p,p,p,p)}{\partial p_1} = -1$.

Taking the difference between Equations 42 and 44 and rearranging yields:

$$h(p_b) - h(p_s) = \mu \frac{\partial \Pr_r(p_s, p_s, p_s, p_s)}{\partial p_1}(p_s + S) > 0 \tag{45}$$

$$\leftrightarrow h(p_b) > h(p_s) \Leftrightarrow p_s > p_b. \tag{46}$$

Taking the difference between Equations 43 and 44 and rearranging yields:

$$h(p_b) - h(p_c) = \mu \frac{\partial \Pr_\ell(p_c, p_c, p_c, p_c)}{\partial p_1}(p_c + S) < 0 \tag{47}$$

$$\leftrightarrow h(p_b) < h(p_c) \Leftrightarrow p_b > p_c. \tag{48}$$

□

Proposition 4. *The Substitutes Asymmetric game has a unique symmetric pure strategy equilibrium. The equilibrium strategy profile is* (p^*_{isol}, p^*_{pair})*, where* $p_1 = p_3 = p_{pair}$ *and* $p_2 = p_4 = p_{isol}$*. Further* $p^*_{isol} < p^*_s$ *and* $p^*_s < p^*_{pair}$*.*

Proof of Proposition 4. I can express the *Substitutes Asymmetric* equilibrium as the intersection of two best-response functions, evaluated at symmetry. I restrict attention to symmetric strategies in the sense that $p_{isol} := p_1 = p_3$ and $p_{pair} := p_2 = p_4$. I denote the best response for one player that is part of a *pair* of friends by BR_{pair} and the best response for an isolated player by BR_{isol}. The equilibrium then solves,

$$p^*_{isol} = BR_{isol}(p^*_{pair}) \tag{49}$$

$$p^*_{pair} = BR_{pair}(p^*_{isol}). \tag{50}$$

Equations 52 and 53 define the the best-response functions BR_{pair} and BR_{isol} as the solution to the player's first order conditions under symmetry. Since players 1 and 3 are friends, their objective function is identical to the objective function in the Substitutes Symmetric case. Players 2 and 4 are strangers, so their objective function is identical to that in the Baseline case. Lemma 3 implies that best responses solve the first-order conditions. This result also applies in the Substitutes Asymmetric game, because this game combines the best responses from the Substitutes Symmetric and Baseline games.

$$MU_{pair}(BR_{pair}(x), x) := \tag{51}$$
$$\frac{\partial \Pr_\ell(BR_{pair}(x), x, BR_{pair}(x), x)}{\partial p_1} \cdot (BR_{pair}(x) + S) + \Pr_\ell(BR_{pair}(x), x, BR_{pair}(x), x)$$
$$+ \mu \frac{\partial \Pr_r(BR_{pair}(x), x, BR_{pair}(x), x)}{\partial p_1} \cdot (BR_{pair}(x) + S) = 0,$$
$$MU_{isol}(y, BR_{isol}(y)) := \tag{52}$$
$$\frac{\partial \Pr_\ell(y, BR_{isol}(y), y, BR_{isol}(y))}{\partial p_2} \cdot (BR_{isol}(y) + S) + \Pr_\ell(y, BR_{isol}(y), y, BR_{isol}(y)) = 0.$$

In the *Substitutes Symmetric* game, all players have the same utility function as the pair in the Substitutes Asymmetric game. Therefore, we can characterize the equilibrium as the intersection of BR_{pair} and its inverse.

$$\begin{aligned} y &= BR_{pair}(x), \\ x &= BR^{-1}_{pair}(y), \\ p^*_s &= x = y. \end{aligned}$$

This characterization facilitates comparisons between the equilibria of the asymmetric and symmetric networks. Both networks are at the intersection of BR_{pair} with another best response: either BR_{isol} or BR^{-1}_{pair}.

I proceed by showing that the best responses exist and are decreasing in the symmetric strategy of the other two players. I use the implicit function theorem to prove this claim. Taking the derivative of $MU_{pair}(BR_{pair}(x), x)$ with respect to both its arguments yields, after plugging in functional forms,

$$\begin{aligned} \frac{\partial MU_1(p_{isol}, p_{pair})}{\partial p_{isol}} &= -p_{pair} - p_{isol} - \mu \cdot (p_{pair} + S) < 0 \\ \frac{\partial MU_1(p_{isol}, p_{pair})}{\partial p_{pair}} &= -1 - p_{pair} - p_{isol} - \mu(-1 + 2p_{pair} + p_{isol} + S). \end{aligned}$$

Observe that the second expression falls in p_{pair} and p_{isol}. Therefore, $\frac{\partial MU_1(p_{isol}, p_{pair})}{\partial p_{pair}} < 0$ if the condition holds if we set $p_{pair} = p_{isol} = 0$. This is the case if $-1 + \mu(1 - S) < 0$, which is implied by $S < 1$ and $\mu > 0$. For the isolated participants we have,

$$\begin{aligned} \frac{\partial MU_2(p_{isol}, p_{pair})}{\partial p_{isol}} &= -1 - p_{pair} - p_{isol} < 0 \\ \frac{\partial MU_2(p_{isol}, p_{pair})}{\partial p_{pair}} &= -p_{pair} - p_{isol} < 0. \end{aligned}$$

Consequently, both marginal utilities are (globally) once continuously differentiable,

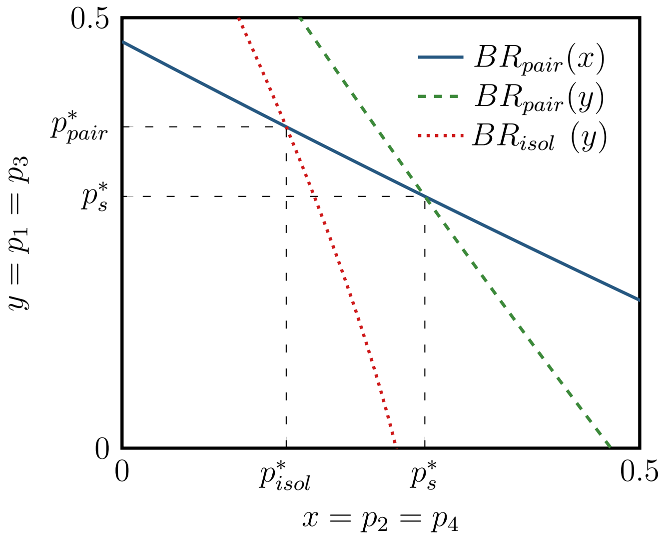


Figure 13: Aggregate best-response functions for the Substitutes Asymmetric (couple and separate) and the Substitutes Symmetric Treatment. Parameters are set at $\mu = 0.8$ and $S = 0.2$.

and the derivatives with respect to the endogenous variable are (globally) different from zero. Therefore, we can apply the implicit function theorem and around each point in the strategy space, and the best responses, evaluated at symmetry, exist and are once continuously differentiable with derivatives

$$\frac{\partial p_{1,coup}(p_{isol})}{\partial p_{isol}} = -\frac{\frac{MU_1(p_{isol},p_{pair})}{\partial p_{isol}}}{\frac{MU_1(p_{isol},p_{pair})}{\partial p_{pair}}} < 0$$

$$\frac{\partial p_{2,sep}(p_{pair})}{\partial p_{pair}} = -\frac{\frac{MU_2(p_{isol},p_{pair})}{\partial p_{pair}}}{\frac{MU_2(p_{isol},p_{pair})}{\partial p_{isol}}} < 0.$$

That is, they are decreasing.

Figure 13 illustrates the best responses in both networks. In the figure, p_1 and p_3 align along the x-axis, while p_2 and p_4 align along the y-axis. The solid blue line indicates the best response of players 1 and 3 who are a pair in both networks. The intersection of this line with the best response of isolated players 2 and 4 (dotted red line) indicates the Substitutes Asymmetric equilibrium point. The intersection of the solid blue line with the best response of paired up players 2 and 4 indicates the Substitutes Symmetric equilibrium. We need to show that the candidate equilibrium point of Substitutes Asymmetric is inside the strategy space and upward and to the left of the Substitutes Symmetric point.

I proceed by showing that the best response of the paired players is always above the best response of the isolated players. That is, we can analyze the change from Substitutes

Asymmetric to Substitutes Symmetric as a rightward shift of best responses. Define

$$h(a,b) := \frac{\partial \Pr_\ell(a,b,a,b)}{\partial p_{pair}} \cdot (a+S) + \Pr_\ell(a,b,a,b),$$

as the private benefit of an increase in p_{pair} or p_{isol}, keeping the other constant. These two are equal because all players' material utilities are the same. By plugging in the functional form assumptions and taking the derivative of h with respect to its first argument (a), we obtain $\frac{\partial h(a,b)}{\partial a} = -1 - a - b < 0$. Therefore, h falls in a.

We use h and Equations 52 and 53 to rewrite the first-order conditions as follows:

$$h(BR_{pair}(y), y) + \mu \frac{\partial Pr_r(BR_{pair}(y), y, BR_{pair}(y), y)}{\partial p_1} \cdot (BR_{pair}(y) + S) = 0 \tag{53}$$

$$h(BR_{isol}(y), y) = 0. \tag{54}$$

These two equations imply

$$h(BR_{isol}(y), y) - h(BR_{pair}(y), y) = \mu \frac{\partial Pr_r(BR_{pair}(y), y, BR_{pair}(y), y)}{\partial p_1} \cdot (BR_{par}(y) + S) > 0$$
$$\Leftrightarrow h(BR_{isol}(y), y) > h(BR_{pair}(y), y),$$

and because h is falling in its first argument, $BR_{isol}(y) < BR_{pair}(y) \quad \forall y \in [0, 0.5]$.

For the Substitutes Asymmetric equilibrium candidate to be interior equilibrium, $BR_{isol}(y)$ and $BR_{pair(x)}$ need to intersect within the strategy space. Since the best responses are continuous, we need to show that within the strategy space, $BR_{isol}(y)$ starts out above $BR_{pair(x)}$ and ends up below it. Then, because of the intermediate, it intersects $BR_{pair(x)}$, and the equilibrium is interior.

The best response of the isolated players $BR_{isol}(y)$ starts out above $BR_{pair(x)}$ if $BR_{isol}^{-1}(0) > BR_{pair}(0)$, which is the case if

$$\frac{\sqrt{\mu^2(S+1)^2 - 2S + 2} + \mu(1-S) - 1}{2\mu + 1} < \sqrt{1-2S}.$$

which is the case for the bounds we impose on μ and S.

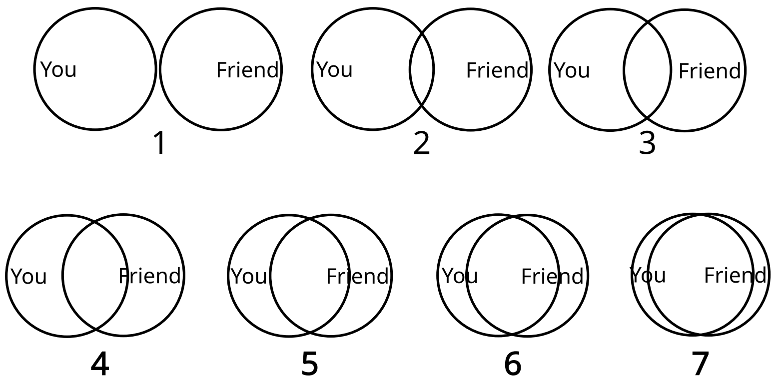
The intersection of BR_{isol} with the x-axis is below BR_{pair} and within the strategy space. We know that the Substitutes Symmetric equilibrium exists and is interior. Furthermore, the best response of the isolated player is below the best response of the pair ($BR_{isol}(y) < BR_{pair}(y) \quad \forall y \in [0, 0.5]$). Moreover, $BR_{isol}(0) > 0$ because players want to charge positive prices to obtain positive profits.

Therefore, the Substitutes Asymmetric game has an interior equilibrium.

Since best responses are decreasing, and $BR_{isol}(y) < BR_{pair}(y) \quad \forall y \in [0, 0.5]$, $BR_{isol}(y)$ intersects $BR_{pair}(x)$ to the left and above (p_s^*, p_s^*). Therefore, $p_{pair}^* > p_s^*$ and $p_s^* > p_{isol}^*$. $\square$

C Survey Questions

- Did you bring your best friend with you? [yes, no]
- How many hours do you and the friend you brought with you spend together every week? [number between 0 and 168]
- How many hours do you spend with other friends each week in total? [number between 0 and 168]
- Trivia question (one of the following):
  - Are you vegetarian or vegan? [yes, no]
  - What time do you usually wake up on weekdays? [hourly brackets from before 5 am to after 11 am]
- What do you think your friend answered to the last question? If you are correct, you will receive a prize of 10 thalers. [same as the trivia question]
- Which of the following pictures best describes your friendship?



- Are you in a romantic or sexual relationship with your friend? [yes, no, do not want to say][36]
- In general, how willing or unwilling are you to take risks? [integers from "0 – Not at all willing to take risks" to "10 – Very willing to take risks"]

I summarize the answers to the friendship part of the survey in Table 5.

[36] Answering this question was voluntary, since romantic or sexual relationships are a sensitive topic. Seven people declined to answer.

Table 5: Summary of answers to the introductory survey.

Statistic	Obs	Mean	Std. Dev.	Min	Max
Romantic Relationship	428	0.30	0.46	0	1
Time with Friend (h/week)	440	30.74	38.87	0	168
Time with Others (h/week)	440	14.11	13.57	0	100
Best Friend	440	0.60	0.49	0	1
IOS	440	4.97	1.52	1	7
Correct Trivia	440	0.86	0.34	0	1

D Comprehension Questions

The *Duopoly* experiment asked the following comprehension questions (the wording depended on whether participants chose prices (Bertrand) or quantities (Cournot)).
Bertrand (price choice).

1. The other firm's demanded quantity, [*decreases*, *increases*], when you raise your price.

2. The other participant's profit, [*decreases*, *increases*], when you raise your price.

3. Suppose the other firm's price is 0. Increasing the other firm's price becomes [*less worthwhile*, *more worthwhile*] the higher your own price is.

Cournot (quantity choice).

1. The other firm's price, [*decreases*, *increases*], when you increase your quantity.

2. The other participant's profit, [*decreases*, *increases*], when you increase your quantity.

3. Suppose the other firm's quantity is 0. Increasing the other firm's quantity becomes [*less worthwhile*, *more worthwhile*] the higher your own quantity is.

The *Network* experiment asked the following comprehension questions.
Land Market.

1. The probability that you (Participant UL) will sell your property, [*decreases*, *increases*], when Participant LL raises the price.

2. The probability that you (Participant UL) will sell your property, [*decreases*, *increases*], when Participant UR raises the price.

3. The probability that you (Participant UL) will sell your property, [*decreases*, *increases*], when Participant LR raises the price.

4. When you (Participant UL) raise your price, [*decreases*, *increases*] the probability that the buyer will purchase property LL.

5. When you (Participant UL) raise your price, [*decreases*, *increases*] the probability that the buyer will purchase properties UR and LR.

Together with each batch, I showed participants a map of the experimental land market (see Figure 14).

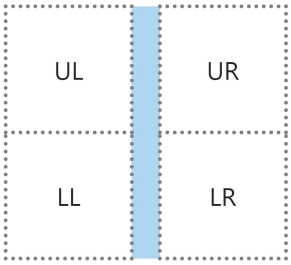


Figure 14: Map that I showed before each batch of comprehension questions.

E Buyer and Seller Payoffs

I calculate buyer and seller payoffs analogously to total welfare.

F Ruling Out Minimal Group and Order Effects

I addressed two potential confounds: minimal group effects and order effects.

To balance minimal group effects, I conducted the experiment using a building condition and a bridge condition. The building condition works as described previously. In contrast, the bridge condition flips the framing: The seller wants to buy a bridge, adjacent plots on opposite sides of the river are complements, and plots on the same side of the river are substitutes. I run half of all sessions in either condition. If the river induces minimal group effects, this procedure balances them across treatments and rules them out as a confounder.

Order effects can occur when the order in which participants make decisions affects their subsequent decisions. To minimize this effect, I used two social network treatment orders.Treatment order A is Substitute Asymmetric, Substitutes Symmetric, Baseline, Complements Symmetric, and Substitutes Asymmetric 2; and treatment order B is Substitute Asymmetric, Complements Symmetric, Baseline, Substitutes Symmetric, and Substitutes Asymmetric.

Table 6: Empirical expected profits (Seller), consumer surplus (Buyer), total surplus, and maximum available surplus. The first panel shows the outcomes for all treatments for the *Network* experiment; the remaining panels split outcomes for the *Duopoly* experiment by interaction type (complements/substitutes) and game (Cournot/Bertrand), reporting Baseline (Friends) vs Treatment (Strangers).

	Seller	Buyer	Total	Max Total
Complements	31.50	41.40	72.9	76.70
Baseline	34.50	36.10	70.60	76.70
Substitutes	35.20	33.10	68.40	76.70

(a) *Network*.

	Seller	Buyer	Total	Max Total
Baseline	118.48	43.55	162.03	298.33
Treatment	122.18	55.02	177.19	298.33

(b) *Duopoly* - Complements — Cournot.

	Seller	Buyer	Total	Max Total
Baseline	131.47	49.23	180.70	298.33
Treatment	136.41	61.00	197.42	298.33

(c) *Duopoly* - Complements — Bertrand.

	Seller	Buyer	Total	Max Total
Baseline	135.96	105.92	241.88	298.33
Treatment	138.62	99.37	237.99	298.33

(d) *Duopoly* - Substitutes — Cournot.

	Seller	Buyer	Total	Max Total
Baseline	115.33	144.22	259.55	298.33
Treatment	119.00	129.46	248.46	298.33

(e) *Duopoly* - Substitutes — Bertrand.

I randomized the transparency treatment order and the order of subsidies within each social network treatment. I attempted to balance the bridge and building conditions across treatment orders.

G Estimation Framework

Treatment effects are estimated as simple differences in means. To estimate clustered standard errors, I use ordinary least squares to regress the price ($p_{i,D,O,S}$) on a treatment indicator (T) and a constant:

$$p_{i,D,O,S} = \alpha + \beta \cdot T + \epsilon_{i,D,O,S}. \tag{55}$$

The treatment indicator (T) and the sample vary across analyses. I index individuals by i, social network treatments by D (Baseline, Substitutes Symmetric, Complements Symmetric, Substitutes Asym. Separate, Substitutes Asym. Couple), the transparency condition by $O = \{public, private\}$, and subsidies by $S \in \{0, 5, 10, 15, 20\}$. Unless specified otherwise, I pool data from both the "public" and "private" treatments and always pool data from different subsidy levels. I cluster standard errors at the friendship-pair level. I implement the estimation with the lfe package (Gaure, 2024).

H Structural Estimation Details

Treatments and notation. I denote the subsidy by $S \in [0, 20]$, the transparency treatment by $O \in \{\text{public}, \text{private}\}$, and the social network treatment by D.[37] I write the (directed) adjacency matrix as $\boldsymbol{M}(D)$ to emphasize that it depends on the network treatment. To allow transparency to affect social sanctions, I let the directed-altruism parameter depend on transparency, $\mu(O)$. Since I focus on symmetric treatments, I adopt player 1's perspective and collect parameters in

$$\gamma = \big(\mu(\text{public}),\, \mu(\text{private}),\, \alpha,\, \rho,\, \lambda\big).$$

Utility and profits. Player i's expected utility equals own expected profit plus altruistic concern for the friend's profit, minus a (public-only) social-image penalty that increases in own price:

$$u_i(\boldsymbol{p}; S, D, O, \gamma) = \pi_i(\boldsymbol{p}; S, D, O, \gamma) + \mu(O)\, \pi_{f(i)}(\boldsymbol{p}; S, D, O, \gamma) \tag{56}$$

$$-\mathbb{1}\{O = \text{public}\} \cdot \rho \cdot p_i. \tag{57}$$

Expected profit is

$$\pi_i(\boldsymbol{p}; S, \gamma) = Pr_\ell(\boldsymbol{p}; \gamma)\, \big(\alpha + S + p_i\big), \tag{58}$$

where $Pr_\ell(\boldsymbol{p}; \gamma)$ denotes the probability that player i makes a sale given the price vector $\boldsymbol{p}$.

Stacking utilities and profits yields

$$\underbrace{\boldsymbol{U}(\boldsymbol{p}; S, D, O, \gamma)}_{\text{expected utilities}} = \underbrace{\boldsymbol{\pi}(\boldsymbol{p}; S, D, O, \gamma)}_{\text{own profit}} + \underbrace{\mu(O)\, \boldsymbol{M}(D)\, \boldsymbol{\pi}(\boldsymbol{p}; S, D, O, \gamma)}_{\text{altruism term}} - \underbrace{\mathbb{1}\{O = \text{public}\}\, \rho\, \boldsymbol{p}}_{\text{tax on high prices}}, \tag{59}$$

$$\text{where} \quad \boldsymbol{p} = \begin{bmatrix} p_1 & p_2 & p_3 & p_4 \end{bmatrix}^\top, \quad \boldsymbol{U} = \begin{bmatrix} u_1 \\ \vdots \\ u_4 \end{bmatrix}, \quad \boldsymbol{\pi} = \begin{bmatrix} \pi_1 \\ \vdots \\ \pi_4 \end{bmatrix}.$$

Logit quantal response equilibrium. I model heterogeneity in choices using logit-QRE (McKelvey and Palfrey, 1995). Let $\mathbb{P}$ denote the (finite) set of feasible prices, and

[37] D indexes the social networks used in the experiment.

let σ_i be player i's probability distribution over $\mathbb{P}$. Player 1's choice probabilities satisfy

$$\sigma_1(p_1; S, D, O, \gamma) = \frac{\exp\Big(\lambda\, \mathbb{E}_{p_2,p_3,p_4}\big[u_1(p_1, p_2, p_3, p_4; S, D, O, \gamma)\big]\Big)}{\sum_{p_1' \in \mathbb{P}} \exp\Big(\lambda\, \mathbb{E}_{p_2,p_3,p_4}\big[u_1(p_1', p_2, p_3, p_4; S, D, O, \gamma)\big]\Big)}. \tag{60}$$

The expectation is taken over opponents' mixed strategies:

$$\begin{aligned}\mathbb{E}_{p_2,p_3,p_4}[u_1(p_1, p_2, p_3, p_4; S, D, O, \gamma)] = \sum_{p_2 \in \mathbb{P}} \sum_{p_3 \in \mathbb{P}} \sum_{p_4 \in \mathbb{P}} & \sigma_2(p_2; S, D, O, \gamma) \\ & \cdot \sigma_3(p_3; S, D, O, \gamma) \\ & \cdot \sigma_4(p_4; S, D, O, \gamma) \\ & \cdot u_1(p_1, p_2, p_3, p_4; S, D, O, \gamma).\end{aligned} \tag{61}$$

Estimation. I estimate γ by quasi-maximum likelihood. Solving for the QRE fixed point would require jointly determining $(\sigma_1, \sigma_2, \sigma_3, \sigma_4)$ from their best-response conditions. Instead, following the empirical payoff method of Bajari and Hortaçsu (2005), I substitute observed choice frequencies for opponents' equilibrium beliefs. Concretely, for observation j with treatments (S_j, D_j, O_j), I replace (e.g.) $\sigma_2(p_2; S_j, D_j, O_j, \gamma)$ by the empirical frequency with which a player in role 2 chooses p_2 under (S_j, D_j, O_j).

Let $j \in \{1, \dots, N\}$ index observations and let p_{1j} denote player 1's realized price in observation j. The estimator is

$$\hat{\gamma} = \arg\max_{\gamma} \sum_{j=1}^{N} \log\Big(\sigma_1(p_{1j}; S_j, D_j, O_j, \gamma)\Big). \tag{62}$$

Standard errors are computed using cluster-robust (Huber–White) sandwich estimators, clustered at the friendship-pair level, as implemented in Zeileis (2006).

I Mechanisms Behind the Lack of Equilibrium Spillover of Friendships

This section explores two mechanisms behind the lack of equilibrium spillovers: decision error and biased beliefs. While data are relatively unlikely to be explained purely by decision error, participants' biased beliefs could explain the lack of equilibrium spillover.

The structural model from the preceding section makes quantitative out-of-sample predictions for the equilibrium effects of friendships. To calculate these predictions I plug the friend's actual behavior in the asymmetric treatment into the QRE-best response function estimated on the symmetric treatments. This method results in an average predicted spillover effect of -0.4. This prediction is narrowly outside of the 95% confidence interval of the observed effect.

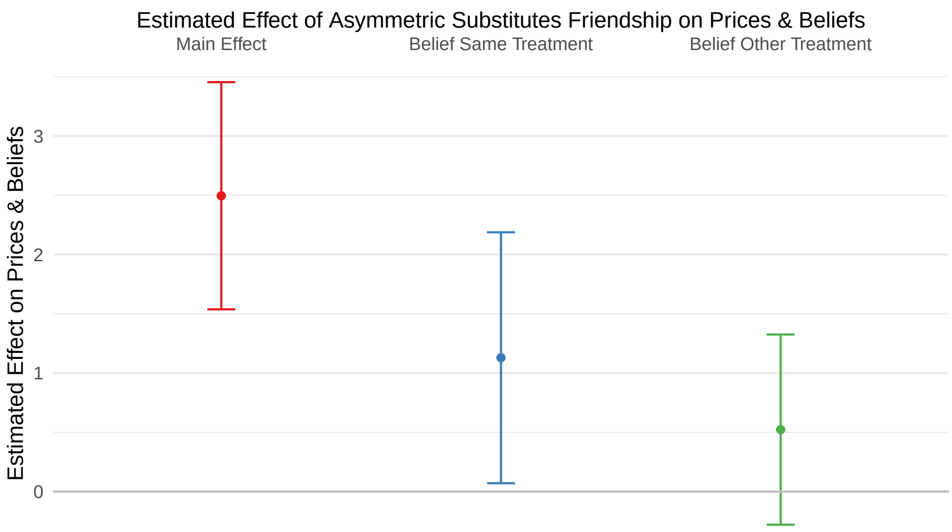


Figure 15: Main effect of an asymmetric link among sellers of substitutes, including corresponding first-order beliefs.

Having examined decision error under the assumption of correct beliefs, we can test that assumption. Figure 15 reports the effect of a substitute friendship on all participants in the asymmetric network. The isolated participants underestimate the effect of the pair's friendship. This insensitivity in beliefs likely explains the under-reaction in terms of prices.

J Belief Elicitation

I elicited each player's beliefs regarding the expected value of other players' prices. Participants had to express distinct beliefs about each other player's price, even if the players were completely symmetric.

The belief-elicitation process was incentivized with the binarized scoring rule (Hossain and Okui, 2013). Players could win a prize based on a specific probability. This probability decreased with the squared distance between the belief and the actual price. This scoring rule is incentive compatible for expected utility maximizers.

I took additional steps to ensure that participants stated their expected value of other players' prices. I informed participants that more accurate beliefs would result in higher payoffs, and they could open a collapsed text box to view the exact scoring rule. This approach aligns with best-practice methods (Danz et al., 2022), wherein participants can request the scoring rule at the end of the experiment. Participants could not hedge because either a belief task or one of the rounds was randomly chosen for payout (Blanco et al., 2010).

K Changing Mode of Competition

Table 7: Regression of strategies on a Bertrand competition dummy, the friendship dummy, and their interaction. Regressions are run separately for complements and substitutes.

	Strategy	
	Strategic Complements (1)	Strategic Substitutes (2)
Bertrand (1=Bertrand, 0=Cournot)	-0.60^{*} (0.34)	0.47^{**} (0.21)
Friends (1=Friends, 0=Strangers)	1.11^{***} (0.22)	-0.21 (0.17)
Bertrand × Friends	-0.14 (0.35)	-0.42 (0.26)
Intercept	9.72^{***} (0.22)	7.12^{***} (0.15)
Observations	1,200	1,200
R^2	0.02	0.00
Adjusted R^2	0.02	0.00

Notes: ***Significant at the 1% level; ** at the 5% level; * at the 10% level.
Standard errors (in parentheses) are clustered on the friendship pair level.

Table 8: Strategic complements regressions. Quantity regressions are run separately for substitutes and complements; the collusion measure pools all observations.

	Strategy	Quantity		Collusion Measure
	Pooled	Substitutes	Complements	Pooled
	(1)	(2)	(3)	(4)
Strategic Complements	2.07***	1.27***	−0.88***	0.04
	(0.21)	(0.32)	(0.31)	(0.11)
Friends	−0.42***	−0.21	1.09***	0.33***
	(0.13)	(0.17)	(0.30)	(0.09)
Strategic Complements × Friends	1.45***	−0.34	0.02	−0.09
	(0.20)	(0.31)	(0.37)	(0.12)
Intercept	7.35***	7.12***	10.60***	−0.03
	(0.11)	(0.15)	(0.21)	(0.08)
Observations	2,400	1,200	1,200	2,400
R^2	0.11	0.01	0.03	0.01
Adjusted R^2	0.11	0.01	0.03	0.01

Notes: ***Significant at the 1% level; ** at the 5% level; * at the 10% level.
Standard errors (in parentheses) are clustered at the friendship-pair level.

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Online Appendix

A Beliefs (Supplementary Analyses)

Figures 16 and 17 revisit analyses from Section 3, using beliefs as the dependent variables instead of participants' prices. The belief data contains three observations for each observation in the price data since there are three participants who have a belief about each price. This analysis was preregistered with the hypothesis that beliefs would react in the same direction as the actual variables. Standard errors are clustered at the friendship-pair level of those who formed the belief. Each table caption refers to a figure for the corresponding analysis, where prices serve as the dependent variable instead of beliefs.

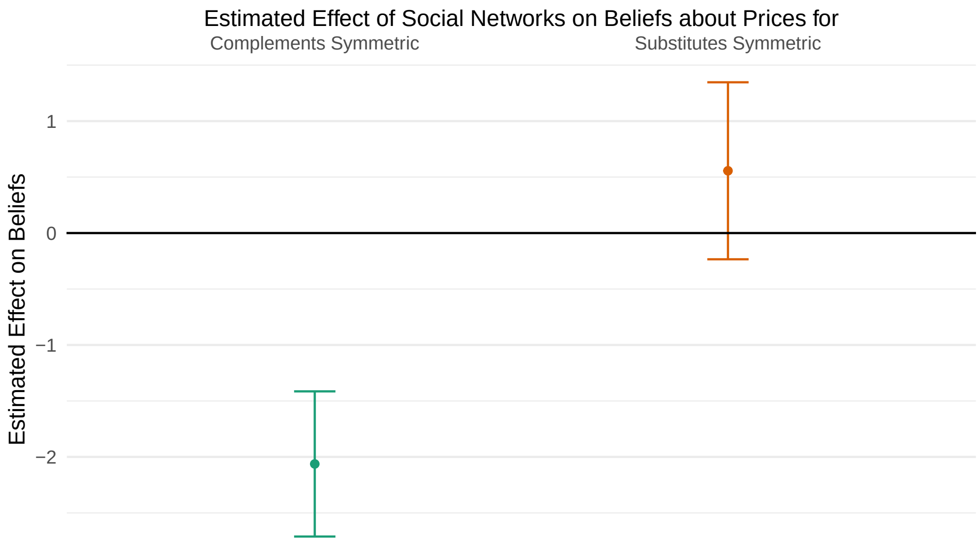


Figure 16: Estimated effect of complement and substitute friendships on beliefs about others' prices. Standard errors are clustered at the friendship-pair level. This figure is analogous to Figure 7.

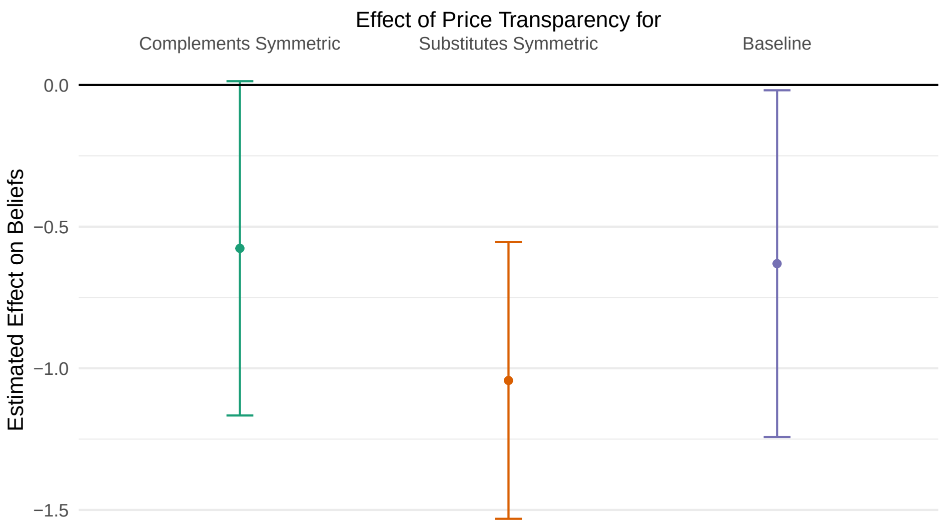


Figure 17: Estimated effects of price transparency on beliefs in the complement symmetric and substitute symmetric treatments. Standard errors are clustered at the friendship-pair level. This figure is analogous to Figure 10.

B Answers to the Open Question on Price Transparency

Figure 18 displays the open question that I asked about the price transparency treatment for the Substitutes Symmetric network. The remainder of this section indicates the answers to this question for the subset of participants that lowered their prices.

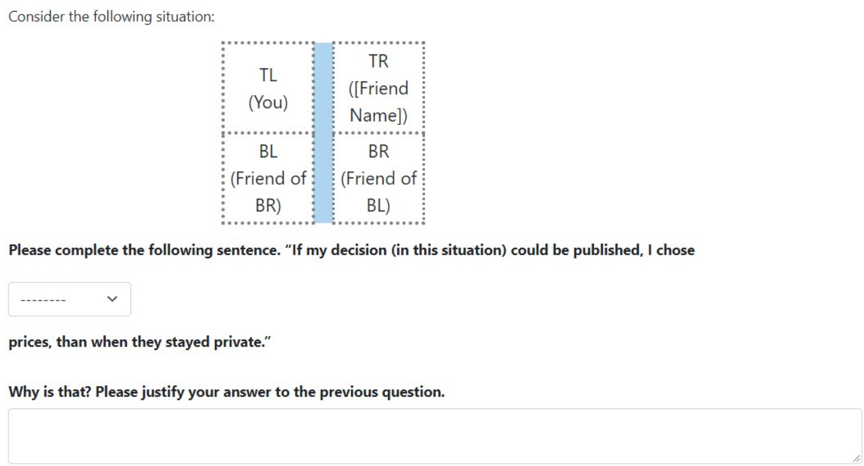


Figure 18: Open question regarding price transparency in the substitutes treatment (translated).

"I think in this situation, I could have created a win for both sides."

"If there is no payout, the disclosed price is not too risky."

“So that I can sell my property with a higher probability.”

“Because I feel safer with a lower price.”

“I was venturesome about staying secret and didn’t want to quote extreme prices that would portray me as greedy. I also expected that a decision that could be published, would be selected.”

“Because I didn’t want to be responsible for a failed sale because I set a high price. ”

“You don’t want to come across in front of others as if you’re just out for the money. In addition, people do not want to be publicly responsible if the other does not receive a price either. ”

“vanity”

“Better lower payouts than no payouts.”

“So my chances of winning are higher.”

“I chose low prices because I suspect that the knowledge about my higher pricing could potentially negatively impact trading.”

“I wanted to choose a lower price so that the probability of selling the property is higher. If I had made the price too high and we had not sold, I would have felt guilty to my counterpart.”

“Because I believe that if the decision could be announced, [name] also chose lower prices.”

“Because I think that many people are more willing to take risks anonymously (myself included).”

“So that I had not chosen too high prices and therefore the upper plots are not sold by me.”

“[name] would see that I chose too high, unpleasant.”

“If it is not anonymous, I do not want to take too high prices myself.”

“Because that decides whether you get the profit.”

“So that I don’t look greedy and I’m not at fault that our site is not bought.”

“So that nobody is angry if they don’t earn money because of me.”

“Probably I would have compared my prices with those of [name] and noticed that hers are lower than expected, so I would have started to set lower ones as well.”

“Social desirability. You didn’t want to disappoint the others by gambling too high.”

“Because you may be faulted afterwards if a purchase does not take place.”

“I didn’t want to overestimate my prices when other participants see that. ”

C Correlation Between Prices

If friends have more accurate beliefs about each other, their prices should be positively correlated when selling substitutes and negatively correlated when selling complements. If my friend sells a substitute and I know he is more likely to ask for a high price than a generic stranger, I am also asking for a higher price because I face less competition. This interaction leads to a positive correlation between the price of substitutes. An analogous argument with the opposite sign holds for the price of complements. In equilibrium, the effect might be magnified for substitutes and attenuated for complements.

I test for the correlation between friends' prices by regressing a person's price on her friend's price interacted with a dummy that indicates if the friend sells a substitute or a complement. I restrict the sample to the Complements Symmetric and Substitutes treatments and the Substitutes Asymmetric couple treatment. I control for player i's prices in the Baseline and Substitute asymmetric separate treatments, a social network treatment indicator, and a player's risk aversion measured by her answer to the general risk question[38]. I cluster standard errors at the friendship-pair level.

Column (1) of Table 9 presents the estimates from the primary specification. Column (2) shows an alternative, non-preregistered specification that includes additional controls for the transparency treatment and a participant's subsidy. For clarity, I omit the main effect of another participant's price and instead report separate coefficients for the price of a friend selling a substitute and a friend selling a complement. According to the theory, the coefficient for the substitute should be positive, while the coefficient for the complement should be negative. However, I do not find any evidence supporting this prediction.

Table 9: Estimated relationship between friends' prices.

	Dependent variable: Price	
	(1)	(2)
Complements · Price Friend	−0.009	−0.031
	(0.053)	(0.055)
Substitute · Price Friend	−0.024	−0.034
	(0.044)	(0.046)
Cost	No	Yes
Secret	No	Yes
Observations	3,000	3,000
R^2	0.361	0.364

Notes: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. Standard errors are clustered at the friendship-pair level.

D Structural Model with Baseline Altruism

I re-estimate the structural model with a baseline altruism parameter. In this specification, participant 1's utility is as follows:

[38]This is a non-incentivized question from Falk et al. (2023): "Please tell me, in general, how willing or unwilling you are to take risks. [scale of 0 to 10]" I use this question in the German translation from Falk et al. (2018). This question reliably correlates with answers on an incentivized lottery choice task (Dohmen et al., 2011) I add a separate dummy for each possible answer to this question.

$$U_1(p_1, p_2, p_3, p_4, S, D, O, \gamma) = m_1(.) + \mu_{bl}(O) \sum_{i=2}^{4} m_i(.) + \mu(O)\pi_{f(i)}(.),$$

where μ_{bl} is the baseline altruism parameter. This implies that people weigh their friend's payoff with $\mu_{bl}(O) + \mu(O)$.

I test whether changes in baseline altruism can explain the effect of price transparency. If participants' prices become more observable, they could react by behaving more altruistically towards all other participants. I estimate different baseline altruism parameters for each price-transparency condition (O) and drop the term for social image concerns from the participant's utility. If participants become more altruistic, their baseline altruism parameter should increase when switching from the private to the public treatment ($\mu_{bl}(public) - \mu_{bl}(private) > 0$).

The estimation suggests that baseline altruism is challenging to estimate. In theory, baseline altruism should drive participants' actions closer to the collusive outcome, which accounts for two opposing externalities of high prices: reduced demand for complements and increased demand for substitutes. As a result, the collusive outcome is similar to the non-collusive one, meaning that baseline altruism has only a minor effect on predicted behavior in the experiment. Consequently, it is difficult to estimate. Table 10 presents the parameter estimates for the model with baseline altruism, where the confidence interval for $\mu_{bl}(private)$ ranges from -0.99 to 0.19.

Table 10: Parameter estimates for the QRE-Directed-Altruism model, incorporating baseline altruism.

Parameter	Explanation	Estimate	95% CI
Baseline Altruism			
$\mu_{bl}(private)$	private	-0.40	$(-0.99, 0.19)$
$\mu_{bl}(public) - \mu_{bl}(private)$	increase public	-0.16^{***}	$(-0.26, -0.047)$
Directed Altruism			
$\mu(private)$	private	0.24^{***}	$(0.17, 0.31)$
$\mu(public) - \mu(private)$	increase public	-0.003	$(-0.077, 0.071)$
α	constant	23^{***}	$(19, 27)$
λ	QRE-parameter	0.25^{***}	$(0.18, 0.31)$

Notes: *p<0.1; **p<0.05; ***p<0.01; standard errors are clusterd on the friendship pair level.

The model estimates indicate that an increase in baseline altruism cannot explain the fall in prices due to increased transparency. Table 10 reports a significant decrease in baseline altruism in response to increasing price transparency. This suggests that a model that uses baseline altruism to explain the effect of increasing price transparency is misspecified.

E Translated Instructions Network Game

This Appendix contains screenshots of the translated o-Tree experiment. The screenshots appear in the same order as the experiment. In cases where the feedback depends on the participants' decisions, I have chosen an illustrative example. I show an example of the decision screen and the belief elicitation. The participants had an annotated copy of the decision screen in front of them. The screen (without the annotations) is shown later in this Appendix. I omit the explanation of the network that is shown before each sets of treatments, since it is included in the main appendix.

Welcome

Dear study participant,

welcome and thank you for participating in our experiment today. Please do not talk to other participants during the experiment.

You can earn money during the experiment. Your payout amount depends on your own decisions and those of the other participants.

This experiment uses the fictional currency thaler. At the end of the experiment, the amount in thalers you have earned will be converted into euros and paid out to you. In this conversion, **2 thalers equal one euro.** In addition, you will receive **€7.50** as compensation for arriving on time for the experiment.

If you have any questions during the experiment, please raise your hand. A study leader will come to your place and answer your question.

Next

Overview

This experiment consists of several rounds. In each round, you will make a decision in a simulated real estate market.

There are different versions of this market. First, we will explain the simplest one. At the end of the explanation, we will ask you a few questions to check your understanding.

All participants take on the role of property owners. Each property owner can offer their property for sale. The potential buyer is simulated by the computer.

You interact with three other property owners. Everyone simultaneously decides on a price at which to offer their property. Then the buyer decides which properties to purchase. Your sales success also depends on the prices of others.

Make this decision carefully! The higher the price at which you sell your property, the more money you earn. However, if it is too high, you will be left with your property and earn nothing.

Next, we will explain the market process in detail. We will go into more detail about the location of the properties, the buyer's decision, and how prices are determined.

Next

Questions

Please answer the following questions.

You have appeared for the experiment with a friend. What is the name of this friend?

Did you bring your best friend with you?

- Yes
- No

How many hours do you and the friend you brought with you spend together every week?

How many hours do you spend with other friends each week in total?

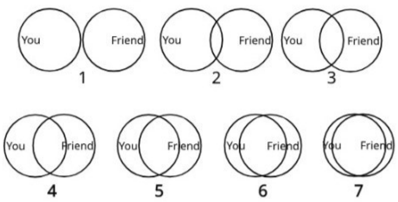
Are you vegetarian or vegan?

- Yes
- No

What do you think your friend answered to the last question? If you are correct, you will receive a prize of 10 talers.

- Yes
- No

Which of the following images best describes your friendship?



Are you in a romantic or sexual relationship with your friend?

In general, how willing or unwilling are you to take risks?

- 0 - Not at all willing to take risks
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Very willing to take risks

Results

[Friend Name] is not vegetarian or vegan. You were correct and will receive 10 thalers for that.

Next

Overview

This experiment consists of several rounds. In each round, you will make a decision in a simulated real estate market.

There are different versions of this market. First, we will explain the simplest one. At the end of the explanation, we will ask you a few questions to check your understanding.

All participants take on the role of property owners. You and the other property owners can offer your property for sale. The potential buyer is simulated by the computer.

You interact with three other property owners. Everyone simultaneously decides on a price at which to offer their property. Then the buyer decides which properties to purchase. Your sales success also depends on the prices of others.

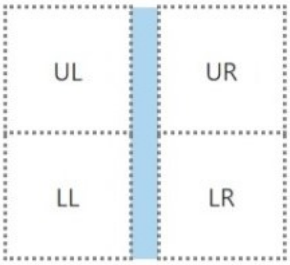
Make this decision carefully! The higher the price at which you sell your property, the more money you earn. However, if it is too high, you will be left with your property and earn nothing.

Next, we will explain the market process in detail. We will go into more detail about the location of the properties, the buyer's decision, and how prices are determined.

Next

Position of the Properties

You and the three other participants each own a property. You can see the positions of all properties on the following map.



Your property is located at the upper left (Position "UL").

The roles LL, UR, and LR will be taken by various other participants during the experiment. You will find out if and in which role [Friend Name] is participating in the current round. If two of the other property owners are friends, you will also find out. All participants know which property owners are friends. Only friendship pairs know each other's identities.

We refer to you and the other property owners according to the positions of the properties as "upper left (UL)", "lower left (LL)", "upper right (UR)", and "lower right (LR)".

The properties UL and LL are separated from UR and LR by a river.

Next

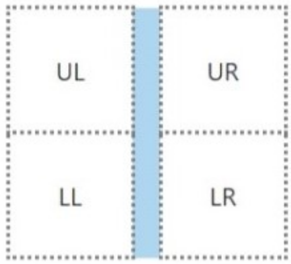
Price Formation

All participants decide on a property price. You make this decision **without knowing the prices of the other participants.** You may find out the prices the other participants chose after the experiment is over. But more on that later.

If the buyer purchases your property, you will receive your price in thalers. The same applies to the other participants. Those who do not sell their property will earn nothing in that round.

Sometimes the sale of properties is subsidized. We will explain the details later.

We refer to your price as p_{UL}. The price for the property LL on your (the left) side of the river is called p_{LL}. The prices for the properties UR and LR on the right side of the river are called p_{UR} and p_{LR}.



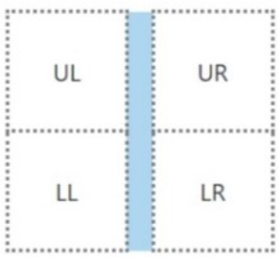
Buyer's Decision: Valuations and Prices

The buyer wants to build a large building that requires two plots of land. This building cannot be built over the river. Therefore, the buyer wants to buy **two plots of land on the same side of the river** (i.e., either UL and LL or UR and LR).

The buyer's decision is based on his valuation. The valuation for both plots on the left side of the river together is a **randomly selected amount between 0 and 100 thalers.** The valuation for both plots on the right side of the river together is another randomly selected amount between 0 and 100 thalers. It is independent of the valuation for the plots on the left side of the river. In the selection of valuations, every number between 0 and 100 is equally likely. The valuations can have many decimal places. Therefore, they are always different from each other.

You must decide on a selling price without knowing the buyer's valuation.

Since the buyer only buys the plots on one side of the river as a package, his decision is based solely on the **sum of the respective prices.** The price for the plots on the left side of the river is $p_{UL} + p_{LL}$, and the price for the plots on the right side of the river is $p_{UR} + p_{LR}$.

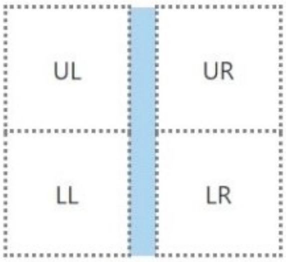


Next

Buyer's Decision: Purchase Probability

High valuations and low prices increase the probability of a purchase. The buyer buys the pair of plots where the **difference between valuation and price is greatest.** If the price for both pairs of plots exceeds the valuation (i.e., the difference is negative), he does not buy at all.

The valuation for the two plots on the left side of the river differs from the valuation for the two plots on the right side of the river. Therefore, if the valuation for the two plots on the left side of the river is higher, the buyer may buy the left plots even if the right plots are cheaper – and vice versa.



Examples

Assume the following decisions for the two examples on this page:

- **You (Participant UL)** decide on a price of p_{UL} **= 20 thalers,**
- **Participant LL** decides on p_{LL} **= 30 thalers,**
- **Participant UR** decides on p_{UR} **= 35 thalers** and
- **Participant LR** also decides on p_{LR} **= 30 thalers.**

The total price for the two plots **on the left** side of the river is therefore **50 thalers,** and the total price **on the right** side of the river is **65 thalers.**

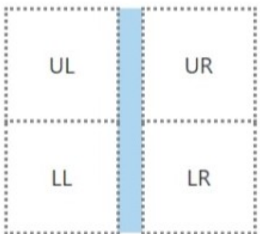
Example 1

Assume that the randomly drawn **valuation** of the buyer for the two plots **on the left** side of the river is **20 thalers** and the **valuation** for the two plots **on the right** side of the river is **80 thalers**.

The total price for the two plots on the left side of the river exceeds the buyer's valuation: **50 thalers > 20 thalers.**
The total price for the two plots on the right side of the river is less than the buyer's valuation: **65 thalers < 80 thalers.**
Therefore, the buyer buys the two plots on the right side of the river. **Participant UR** gets p_{UR} **= 35 thalers** and **Participant LR** gets p_{LR} **= 30 thalers.** Participants UL and LL get nothing.

Example 2

We stay in the previous situation with one difference: The **valuation** for both plots on the **left** side is now **81.396 thalers.** This means that the price on both sides is less than the valuation. Therefore, the buyer buys on the side with the larger difference between valuation and price.
The **difference** between valuation and price **on the left** side of the river is **81.396 thalers – 50 thalers = 31.396 thalers**.
The **difference on the right** side of the river is **80 thalers – 65 thalers = 15 thalers**.
The **buyer buys on the left** side of the river, Participant **UL** gets p_{UL} **= 20 thalers**, and Participant **LL** gets p_{LL} **= 30 thalers**. Participants UR and LR get nothing.



Next

Comprehension Questions 1

Complete the following sentences to make a correct statement.

Question 1 The probability that you (Participant UL) will sell your plot

falls

, if Participant LL increases the price.

Question 2 The probability that you (Participant UL) will sell your plot

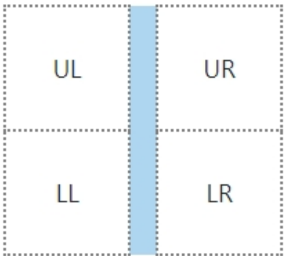
rises

, if Participant UR increases the price.

Question 3 The probability that you (Participant UL) will sell your plot

rises

, if Participant LR increases the price.



Next

Resolution of Comprehension Questions

Question 1
Correct! The LL plot is on the same side of the river as your plot (UL). A higher price from Participant LL increases the total price for both plots on the left side of the river. The higher total price lowers the probability of selling your plot (UL).

Question 2
Correct!

Question 3
Correct!

Explanation for Questions 2 and 3
The plots UR and LR are on the other side of the river. If one of the participants increases the price, the total price for both plots on the right side of the river increases. Thus, the plots on the left side of the river become relatively more attractive. The buyer is more likely to buy from you (the probability increases).

Next

Comprehension Questions 2

Complete the following statements to make a correct statement.

Question 1
If you (Participant UL) increase your price, the probability that the buyer will purchase the LL plot

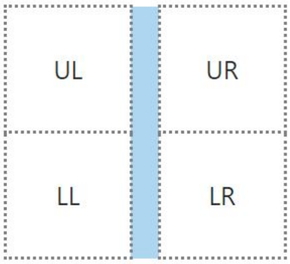
falls

.

Question 2
If you (Participant UL) increase your price, the probability that the buyer will purchase the UR and LR plots

rises

.



Next

Resolution of Comprehension Questions

Question 1
Correct! The plot of Participant LL is on the same side of the river as yours (left). A higher price from you (Participant UL) increases the price for both plots on the left side of the river. The higher price lowers the probability that Participant LL will sell his/her plot.

Question 2
Correct! A higher price from you (Participant UL) increases the price for both plots on the left side of the river. The plots of Participant UR and LR are on the other side of the river (right). The plots on the right side of the river become relatively more attractive due to the price increase on the left. The probability that the buyer will purchase UR and LR increases.

Next

Outline

In the following, you will make decisions in various rounds of this market. At the end of the experiment, **one** of these decisions will be selected for payment. You will receive your earnings from this decision in addition to the reward for attending the experiment and your earnings from the previous questions. Each of these rounds proceeds as follows.

1. You will find out whether and in what role [Friend Name] participates in the market. You will also find out if there are friendships between the other landowners.
2. You will find out whether and to what extent the sale of your plot is subsidized.
3. All participants choose their prices simultaneously.
4. The buyer's valuations are randomly selected.
5. The buyer makes his purchase decision.
6. All participants whose plots were purchased receive their respective prices paid out.

Before you begin making your decisions, we will familiarize you with the user interface and a few special rules.

Next

Decision Screen: Overview

On the table in front of you, there is an example of a decision screen. We will give you an overview using this example. We will explain the details on the next two pages.

In part **A** at the beginning of the screen, any **special rules of the current decision** are explained. This includes whether the sale of the plot is subsidized and whether your decision remains confidential. **The same rules apply to all participants for a specific decision.**

Then you can decide on a price (**B**). This is followed by a tool designed to help you with this decision (**C**).

On the following pages, we will explain these elements in detail.

Next

Decision Screen: Subsidies

As mentioned before, in some rounds the sale of the plot is subsidized. If you **sell your plot,** a **subsidy** will be **added** to your payout. If you **do not sell your plot,** you will **not receive any subsidy.** If there is a subsidy, it is the same for all participants.

For example, if a potential subsidy of 10 thalers is to be paid in the current round, you will see the following message at the beginning of the decision screen:

+10 You and all other participants will receive a **subsidy of 10 thalers** if you sell your plot.

In this case, your payout if you **sell your plot is p_{UL} + 10 thalers.** If you **do not sell your plot,** the payout is as usual **0.**

Next

Decision Screen: Information About Prices

For each market variant, it is separately regulated what information you receive about the prices of other participants and what information the other participants receive about your price. If you receive information, it is only **at the end** of the experiment. Neither you nor the other participants have the chance to learn from the consequences of your decisions during the experiment.

Secret Decision

If the price you decided on remains **secret,** you will see the following message at the beginning of the decision screen:

> Your price and the other participant's prices remain **secret** . If a trade occurred and at what price also remains **secret** .

In some rounds, there is a possibility that the other participants will **learn your price and the market outcome at the end of the experiment.** However, this only happens if the corresponding round is selected for payout. The same round is always selected for payout for all participants assigned to each other. If the other participants learn your price, you will also learn the prices of the other participants.

Public Decision

If your decision might be made public, you will see the following message at the beginning of the decision screen:

> Attention! If this round is selected for payout, your price, and the other 3 participants' prices will be **published** in this group at the end of the experiment.

Assume that Round 2 could potentially be made public and Round 2 was selected for payout. In this case, at the end of the experiment, you will see the following overview of your decisions, the decisions of the other participants, and the market outcome. (All numbers and the different participants in the market are arbitrarily chosen examples.)

> **Round 2** was selected for payout. The following image shows participants' prices.

UL (You) p_{UL} = 5		UR (Stranger) p_{UR} = 8
LL ([Friend Name]) p_{LL} = 7		LR (Stranger) p_{LR} = 15

- The buyer bought the two plots **on your side of the river**.
- All participants potentially (if they sold their plot) got a **subsidy of 5.**
- Your payoff from this round is **10 thalers.**

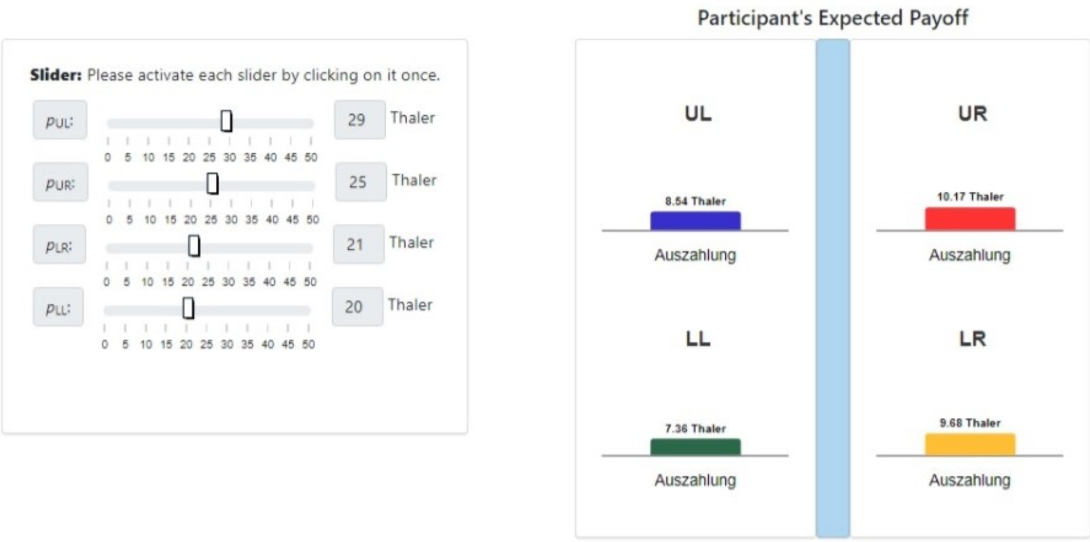
Next

Decision Screen 2: Tool for Simulating the Market

Please activate all sliders by clicking once to display the graphic with the expected payouts.

Each decision screen contains a tool. This tool allows you to simulate the expected outcome of the market. On the sliders to the left of the screen, you can set the prices of the various participants. The set price is displayed to the right of the sliders. The bars in each plot represent the expected payout of all participants. The expected payout is the price you have chosen multiplied by the probability that the buyer has valuations that make him buy your plot.

Below you can see an example of this tool in the case without subsidies. **Please activate each slider by clicking on it once. Only then will the bars with the expected payouts appear.**

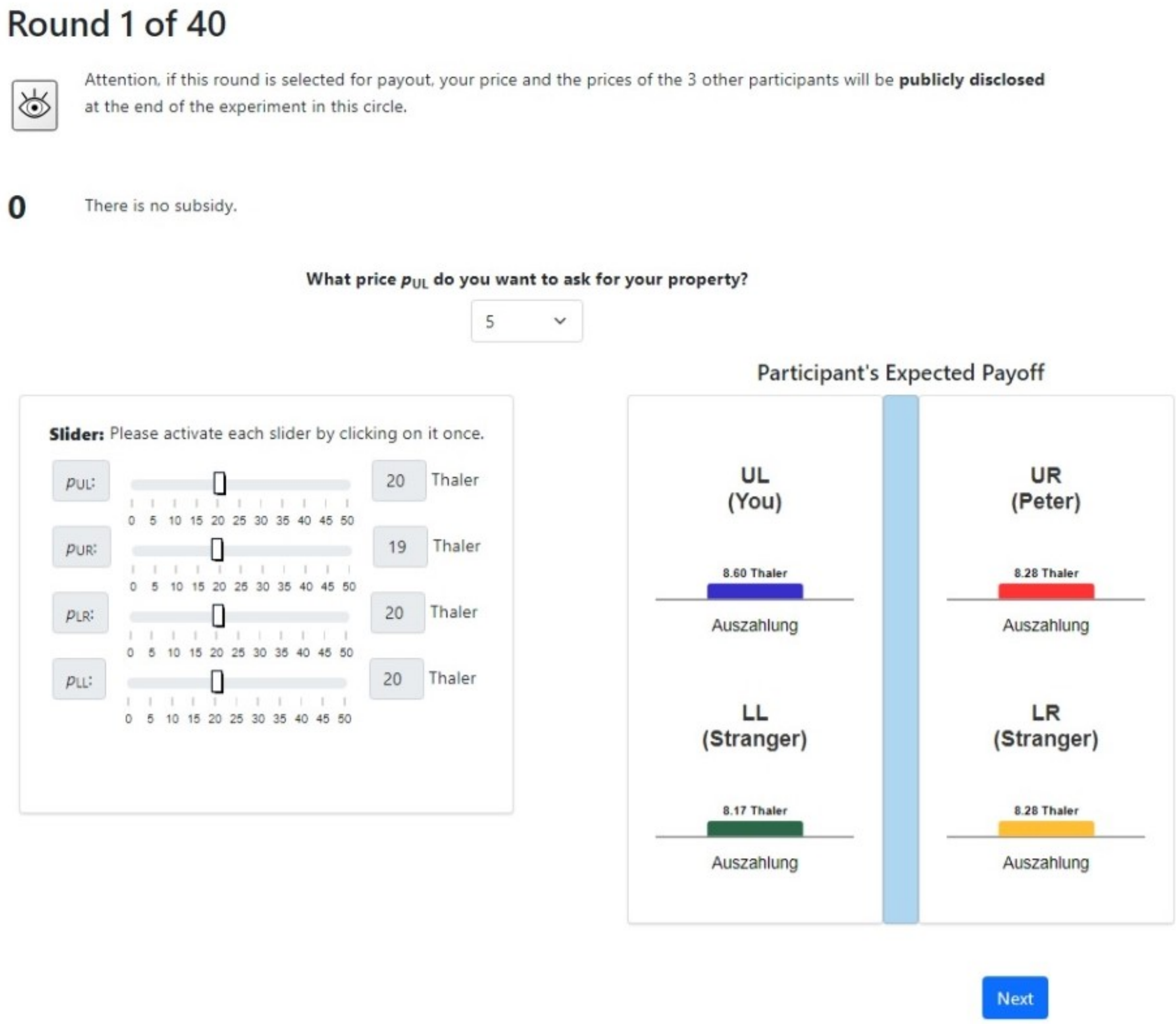


If plot sales are subsidized, the tool automatically adds the correct subsidy.

You can use this tool to play out what would happen with different decisions (your decision and those of the other participants). Experiment with the sliders until you have decided on a price.

You will now begin making your decisions.

Next


Round 1 of 40
Attention, if this round is selected for payout, your price and the prices of the 3 other participants will be **publicly disclosed** at the end of the experiment in this circle.
0
There is no subsidy.
What price p_{UL} do you want to ask for your property?
5
Participant's Expected Payoff
Slider: Please activate each slider by clicking on it once.
p_{UL}:
20
Thaler
p_{UR}:
19
Thaler
p_{LR}:
20
Thaler
p_{LL}:
20
Thaler
0 5 10 15 20 25 30 35 40 45 50
UL
(You)
8.60 Thaler
Auszahlung
UR
(Peter)
8.28 Thaler
Auszahlung
LL
(Stranger)
8.17 Thaler
Auszahlung
LR
(Stranger)
8.28 Thaler
Auszahlung
Next

Additional Question Round 1

Now we would like to ask you about your guess about the decisions of the other participants **in the situation just presented to you.**

For your guess you can earn a **price of 10 thalers.**

Please give the value that actually reflects your guess. The chance to receive the price is higher the closer your guess is to the actual value.

exact payout rule

We first calculate the quadratic deviation of your guess from the actual decision of the corresponding participant. The probability of winning the price is 1-(quadratic deviation/2500). If you are exactly right, this expression is 1. If you are maximally wrong, it is 0.

As a reminder: Only one decision in the experiment will be randomly selected for payout. This means that either this estimation task or one of the decisions you have made so far will be payout relevant. If this task is selected, one of the guesses will again be randomly selected for payout.

What price do you think Participant LL (Stranger) set?

5

What price do you think Participant UR (Peter) set?

14

What price do you think Participant LR (Stranger) set?

12

Next

Some Final Questions

Consider the following situation:

TL (You)	TR ([Friend Name])
BL (Friend of BR)	BR (Friend of BL)

Please complete the following sentence. "If my decision (in this situation) could be published, I chose

lower

prices, than when they stayed private."

Why is that? Please justify your answer to the previous question.

Besides your friend, do you know any other participant in this experiment on a personal level?

- Yes
- No

Do you agree with the following statement "I am a better at predicting what price [Friend Name] is asking for than what a stranger is asking for."

- Yes
- No

Do you have any comments about the experiment?

Next

F Translated Instructions Duopoly Game

The instructions to the duopoly game, as far as they differ from the *Network* game, are printed below.

Market Procedure

You take the role of one of two firms selling a similar product. The other firm is represented by another participant.
In each round, all participants decide how much of their product to supply. You make this decision without knowing the other firm's quantity.
Your profit in a round equals the *price* multiplied by the *quantity demanded*.
The computer sets the price as a function of your quantity and the other firm's quantity.

Important rules.

- The higher your quantity, the lower the price.
- Beyond a certain quantity, the price falls to zero.
- The other firm's quantity can additionally increase or decrease your price.

The other firm's demand and profit are calculated according to exactly the same rules.
We will always inform you how the price is calculated. In addition, we provide a calculator that allows you to compute your profit and the other firm's profit for any pair of quantities.
On the next pages, we first explain the elements of the decision screen using an example.
This is followed by two additional examples, each with comprehension questions.

Example: Elements of the Decision Screen

At the top of the decision screen, you are informed how the computer determines the price.

> If both quantities are 0, the price is **20**.
> An increase of your quantity by **1** **lowers** your own price by **2**.
> An increase of the quantity of the other firm by **1** **raises** your own price by **1**.

We first consider a simple example: Suppose you choose a quantity of 4 and the other firm chooses a quantity of 2. Then your price is

$$20 - 2 \cdot 4 + 1 \cdot 2 = 14.$$

The other firm's price, following the same rule, is

$$20 - 2 \cdot 2 + 1 \cdot 4 = 20.$$

Decision Aid (Tool)

Further down on each decision screen there is a tool that allows you to simulate the market outcome.
Using the sliders on the left side of the screen, you can set the quantities of the different participants. The selected quantity is shown to the right of each slider. The bars on the right side of the screen display the payoffs of all participants. A payoff equals the quantity you chose multiplied by the price. The price depends on your quantity and the other participant's quantity.
Here you see an example of this tool.

[Picture of the Decision Aid
compare Figure 5a in Section 1 in the main text.]

Simulated Profits

You can use this tool to explore what would happen under different decisions (your decision and the other participant's decision). Try different slider positions until you have made your decision.