Price Competition and Cooperation on Sustainable Investments*

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Abstract

Competition policy is increasingly employed to orchestrate cooperative investment agreements in industries. This paper investigates how potential cooperation between firms on corporate social responsibility (CSR) investments affects price competition. The experiment implements communication among sellers in some treatments during the investment stage, using free-form chat or more restrictive messages focused on the CSR investment decision. These alternative communication treatments act as a proxy for the competition authorities' ability to monitor and scrutinize firms' cooperative investment agreements. Treatments also vary costs and demand so that either investment or noninvestment is a profit-maximizing strategy conditional on noncooperative pricing. The experiment identifies the causal impact of investment on pricing, and how cooperative CSR affects welfare in imperfectly competitive markets. Experimental results reveal that investment rates are significantly lower with rich communication than in more limited communication treatments. Moreover, prices and firm profits tend to be higher when firms can freely exchange information, at the cost of lower consumer welfare. There is also evidence of market conditions leading to lower prices with successful investment.

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1 Introduction

Keeping markets competitive has been a predominant objective of competition policy and antitrust regulation. However, competition and antitrust authorities are gradually altering this core mission by utilising their regulatory toolkit to facilitate industry arrangements that meet broader societal-wide objectives (Shapiro, 2021). Sustainability is an important example, where competition policy is leveraged with the aim to shape markets to stimulate economic activity in conjunction with sustainability-oriented goals. These sustainability goals can be diverse, ranging from adjusting energy production capacity to facilitate energy transition (Kloosterhuis and Mulder, 2015), improving animal welfare in factory farming, investment in more sustainable fishing methods, or minimizing/removing plastics in consumer products, among others.

One concrete proposal is to allow firms at the same level of the supply chain to cooperate on specialisation or joint production agreements on the condition that this generates wider (public) benefits, such as in the aforementioned sustainability examples. Although competition law generally prohibits collusive agreements that restrict or distort competition, the European Union has adopted horizontal block exemption regulations to allow for these cooperative agreements between firms. Similar policy proposals and initiatives are currently being pursued by competition and market authorities in the Netherlands, the UK, and Australia.[1]

A recent literature has emerged that investigates the interaction between horizontal agreements and the impact on sustainable production and consumption (Schinkel and Spiegel, 2017; Schinkel et al., 2022), on investment in corporate social responsibility (CSR) (Schinkel and Treuren, 2024), and on pursuing "green" antitrust in the era of climate change (Schinkel and Treuren, 2021). An overarching conclusion from this predominantly theory-driven line of research is that horizontal agreements do not necessarily induce more sustainability investments. This implies that market outcomes where consumers can potentially reap a fair share of the public benefits to be derived from such industry arrangements is not guaranteed.

In these theoretical papers, quantity or price competition following CSR investments is modeled as a one-shot game, resulting in only two stages in total. Consequently, any collusive outcome—whether on CSR, production, or both—cannot be a Nash equilibrium, because each firm retains an incentive to deviate. By contrast, this paper treats the pricing stage as an indefinitely repeated game, thereby naturally accommodating a broader set of subgame-perfect, collusive equilibria that fall between the non-cooperative and fully collusive extremes. Indeed, our experimental findings indicate that actual equilibrium behavior often lies in this intermediate region. Moreover, unlike previous studies, we employ multiple treatments that vary the amount and quality of communication in CSR coordination, enabling us to investigate not only whether CSR collusion is exempted, but also how different types of communication shape firms' subsequent pricing and production decisions, and ultimately influence consumer welfare.[2]

[1]This broadening of the regulatory scope to allow for more flexible sustainability agreements in industries has a direct parallel with competition authorities facilitating industry arrangements to promote positive externalities from cooperative R&D such as research joint ventures (RJVs). In such contexts, cooperation between firms in imperfectly competitive markets can be welfare enhancing given the existence of technological and informational spillovers from investment (Spence, 1984; Katz, 1986; D'Aspremont and Jacquemin, 1988; Suzumura, 1992; Suetens, 2005; Poyago-Theotoky, 2007).

[2]Relatedly, R&D cooperation may dissipate over time as a result of spillovers from competition (Katz, 1986;

The potential threat of collusive pricing also exists in the context of horizontal agreements targeted towards cooperative sustainable investments. This can distort overall market performance despite the competition authorities' mission-driven sustainability objectives. Since this issue is difficult to answer with only theory, here we design and implement a laboratory market experiment. The experiment implements communication among sellers in some treatments during the investment stage, using free-form chat or more restrictive messages focused on the CSR investment decision. We contribute to the literature by providing experimental evidence on the possible effect of cooperative sustainable investment on price collusion. This also enables us to provide some initial empirical insight into the overall welfare implications of horizontal sustainability agreements.

Although the aforementioned theoretical literature does not explore the "spillover" potential of cooperative investment on price formation, we build on a surprisingly sparse experimental literature on such spillovers. The closest to ours is Suetens (2008), who considers a Bertrand pricing game with differentiated products where duopoly firms can invest in the level of R&D investment. However, we differ and extend her experiment in a few important ways. First, in our model collusion is an equilibrium, due to the indefinitely repeated nature of our pricing game. Second, the level of R&D investment in Suetens (2008) is a continuous variable, whereas we consider a binary investment decision. Third, the message space that firms have in Sueten's study is limited to binding proposals on the level of R&D investment, and if accepted they are automatically implemented. We implement a restrictive communication treatment involving a binary investment (or noninvestment) signal alongside a rich communication treatment allowing for free-form bilateral chat. These alternative communication treatments act as a proxy for the competition authorities' ability to monitor and scrutinize firms' cooperative investment agreements. The rich communication has a greater potential to affect subsequent price decisions. Finally, a novel but fundamental aspect of our experiment (and theoretical model) is that it acknowledges the importance of demand shifts due to sustainability investments.

Cason and Gangadharan (2013) also use a laboratory experiment to study the interaction between R&D cooperation and competition. They find that the propensity to cooperate is lower in competitive market environments. More importantly for the question we are interested in, they find no evidence of a significant spillover effect from cooperation on competition in terms of collusive pricing behavior, even when communication opportunities between producers is introduced. Recently, Gomez-Martinez et al. (2024) experimentally study the cooperation and competition relationship by testing whether allowing for CSR agremeents increases the supply of a "fair" good traded in market setting where an explicit inclusion of a third party in the experiment suffers from a negative externality caused by the trade of an "unfair" good. While preserving price competition between firms, the authors find that CSR agreements do not significantly affect the share of fair goods traded, nor do agreements have any bearing on prices and consumer/producer surplus.

Casoria and Ciccone (2021) experimentally investigate whether upfront investment oppor-

Leahy and Neary, 1997), raising the possibility that cooperative R&D arrangements, such as in the case of RJVs, act as a vehicle to facilitate tacit collusion in the product market (Martin, 1996; Greenlee and Cassiman, 1999; Cabral, 2000; Lambertini et al., 2002, 2003; Miyagawa, 2009; Cooper and Ross, 2009; Sovinsky, 2022).

tunities are conducive to cooperation for players in an infinitely repeated prisoner's dilemma game. Overall, their study reveals a positive relationship between investment and subsequent cooperation. Translating this to a context of environmental sustainability, one lesson which can be derived from Casoria and Ciccone (2021) is that by integrating investment opportunities into policy mechanisms may bring markets and industries more in line with sustainability goals. Our experiment builds on this study by explicitly acknowledging the link between investment and cooperation. Our model considers cooperation on actual investment decisions, and assesses how this subsequently affects price formation. Although price collusion is not part of their model, Casoria and Ciccone (2021, 18) do indicate that their "[...] results suggest that antitrust authorities should be alert to the presence of heavy co-investment activities as they might be an important factor determining the (collusive) behavior of market participants." We look directly into this issue by exploiting the opportunity to communicate as an investment coordination channel between players, which is another key difference between our experiment and Casoria and Ciccone (2021).

Our experiment varies players' opportunity to communicate and coordinate investment decisions to reflect different types of regulatory enforcement, which is important for competition and antitrust authorities. Here we follow Cason (2000) in interpreting communication as akin to lax antitrust enforcement, and prohibiting communication reflecting active antitrust enforcement. In our experiment, prohibiting communication is a baseline treatment, but we differentiate communication opportunities into two separate treatments: one where firms can only send a binary investment signal and the other where firms can exchange information bilaterally and freely through an anonymous chat. These three communication treatments represent the regulatory authority's ability to monitor and inspect the firms' cooperation on investment agreements and their potential effect on price formation in the market.

Treatments also vary costs and demand so that either investment or non-investment is a profit-maximizing strategy conditional on noncooperative pricing. The experimental data reveal that investment rates are significantly lower under rich communication relative to both binary and no communication, and this finding is consistent across both market arrangements. Thus, allowing firms to freely coordinate investment decisions does not effectively boost actual investment levels in this strategic environment. Moreover, prices and firm profits tend to be higher when firms can freely exchange information in the rich communication treatment compared to the case where they have no communication opportunities or can communicate only through binary signaling.

Our findings show that different communication regimes can significantly affect the outcome of CSR agreements, underscoring that the critical policy question is not merely whether coordination on CSR should be exempt from antitrust scrutiny, but rather how much information firms exchange and how extensively authorities can monitor the process. In our experiment, the "restrictive" and "rich" communication treatments represent two extremes of a possible communication spectrum when CSR coordination is allowed, with real-world scenarios likely falling somewhere in between. Although existing studies on CSR collusion exemption typically treat "collusion" or "competition" as binary conditions, our results emphasize the importance of analyzing the more nuanced ways firms interact when implementing agreements.

The rest of the paper is organized as follows. Section 2 introduces the theoretical framework. Section 3 describes our experimental design and procedures. Section 4 presents and analyzes the empirical findings. Section 5 concludes with a discussion of some policy implications.

2 Model

2.1 Demand and Cost Structure

This section presents an oligopoly model to examine the effects of exempting CSR-related cooperation from competition policy on firms' CSR investments, product prices, profits, and consumer welfare. The model serves as the theoretical foundation for the market experiment described in the next section. Specifically, we consider a duopolistic market in which two symmetric, risk-neutral firms (indexed by $i \in \{A, B\}$) engage in a repeated game. In the initial round (round 0), each firm makes a binary CSR investment decision $x_i \in \{0, 1\}$, where $x_i = 1$ denotes investment in CSR and $x_i = 0$ denotes no investment in CSR.[3] Given the initial-round investment outcomes (x_A, x_B), the two firms interact repeatedly by simultaneously setting prices in each of the subsequent rounds. They play infinitely many pricing rounds with a discount factor δ, or, equivalently, they play the first pricing round (round 1) with certainty, followed by an indefinite number of rounds with continuation probability δ.

The investment decisions (x_A, x_B) determine the demand and cost structures that the firms face in each subsequent pricing round. Denoting product i's price by p_i and quantity by q_i, we consider a linear inverse demand function given by

$$p_i = p(q_i, q_j, x_i) = \alpha - \beta q_i - \gamma q_j + w(x_i) \quad \text{for } i, j \in \{A, B\},\ i \neq j, \tag{1}$$

where $\alpha > 0$, $\beta > \gamma > 0$, and $w(1)$ is the representative consumer's willingness to pay (WTP) for firm i's CSR investment. That is, $w(1)$ is the premium the consumer is willing to pay for product i's quality improvement due to the firm's CSR investment, relative to the case of no such investment (i.e., $w(0)$ is normalized to zero without loss of generality).[4] This demand system results from the representative consumer's utility maximization under the following utility function that is quasi-linear in the amount of the composite, numéraire good (z):

$$U(z, q_A, q_B; x_A, x_B) = z - \frac{1}{2}\left[\beta\left(q_A^2 + q_B^2\right) + 2\gamma q_A q_B\right] + \sum_{i \in \{A,B\}} \left[\alpha + w(x_i)\right] q_i. \tag{2}$$

Inverting (1) gives the associated demand function for each product

$$q_i = q(p_i, p_j, x_i, x_j) = a - b\left[p_i - w(x_i)\right] + c\left[p_j - w(x_j)\right] \quad \text{for } i, j \in \{A, B\},\ i \neq j, \tag{3}$$

where $a = \frac{\alpha(\beta - \gamma)}{\Delta}$, $b = \frac{\beta}{\Delta}$ and $c = \frac{\gamma}{\Delta}$, with $\Delta = \beta^2 - \gamma^2 > 0$. Note that $p_i - w(x_i)$ can be interpreted as the effective price adjusted for the quality change resulting from firm i's CSR investment.

[3] In accordance with antitrust guidelines, CSR investments in our model can be interpreted broadly and may relate to investments in product quality, investment in production processes, or sustainability-focused R&D.

[4] Note that $w(1)$ represents the value of the firm's CSR investment as perceived by the consumer, which may differ from its value from a broader social perspective.

In each round, firm i's total cost of producing q_i units, conditional on its investment choice x_i, is given by $m_i(x_i)q_i + F_i(x_i)$, where $m_i(x_i)$ is the marginal cost of production and $F_i(x_i)$ is the fixed cost satisfying $F_i(0) < F_i(1)$. Let us define the quality-adjusted marginal cost as

$$\widehat{m}(x_i) \equiv m(x_i) - w(x_i). \tag{4}$$

Note that $\widehat{m}(0) = m(0)$ since $w(0) = 0$. If $\widehat{m}(0) > \widehat{m}(1)$—or equivalently, if $m(0)-m(1)+w(1) > 0$—then firm i's CSR investment reduces the quality-adjusted marginal cost. In other words, firm i's CSR investment increases the combined net private benefit that an additional unit of the good provides to firm i and the representative consumer. Below we restrict our analysis to cases where $\widehat{m}(0) > \widehat{m}(1)$ for the following reason. As shown in Appendix A, investment collusion improves consumer welfare only if $\widehat{m}(0) > \widehat{m}(1)$. Therefore, this condition $\widehat{m}(0) > \widehat{m}(1)$ aligns with a common criterion used by antitrust agencies when exempting CSR-related cooperation from antitrust regulations: such cooperation must not harm consumers of the relevant good.

2.2 Bertrand-Nash and Collusive Pricing

Two possible benchmark equilibrium paths in the repeated pricing subgame are (i) Bertrand-Nash pricing in every round, and (ii) fully collusive (joint profit-maximizing) pricing in every round. These two cases can be considered the lower and upper bounds within which actual outcomes are likely to fall. We now examine each of these two outcomes in turn.

First, consider the case in which the Bertrand-Nash equilibrium is realized in each pricing round, conditional on the initial investment choices (x_A, x_B). This benchmark serves as a lower bound on the equilibrium prices and payoffs that can arise in the repeated pricing subgame, given (x_A, x_B). The Bertrand-Nash equilibrium price $p^b(x_i, x_j)$, quantity $q^b(x_i, x_j)$ and profit $\pi^b(x_i, x_j)$ for firm i in each round are given by:

$$\begin{aligned} p^b(x_i, x_j) &= \frac{2b\,[a + b\widehat{m}(x_i)] + c\,[a + b\widehat{m}(x_j)]}{4b^2 - c^2} + w(x_i), \\ q^b(x_i, x_j) &= \frac{b\left[2ba + ca - (2b^2 - c^2)\widehat{m}(x_i) + bc\widehat{m}(x_j)\right]}{4b^2 - c^2}, \\ \pi^b(x_i, x_j) &= \frac{q^b(x_i, x_j)^2}{b} - F(x_i). \end{aligned} \tag{5}$$

Proposition 1. *Given that* $\widehat{m}(0) - \widehat{m}(1) = m(0) - m(1) + w(1) > 0$*, we have* $\pi^b(0,1) < \pi^b(0,0)$ *and* $\pi^b(1,1) < \pi^b(1,0)$*. Moreover, depending on the parameter values, the Bertrand-Nash equilibrium payoffs,* $\pi^b(0,0)$*,* $\pi^b(1,0)$*,* $\pi^b(0,1)$*, and* $\pi^b(1,1)$*, follow one of the five orderings listed below:*[5]

(a) $\pi^b(0,1) < \pi^b(0,0) \leq \pi^b(1,1) < \pi^b(1,0)$

(b) $\pi^b(0,1) \leq \pi^b(1,1) \leq \pi^b(0,0) \leq \pi^b(1,0)$

(c) $\pi^b(1,1) \leq \pi^b(0,1) \leq \pi^b(1,0) \leq \pi^b(0,0)$

[5] Consequently, the ordering $\pi^b(0,1) \leq \pi^b(1,1) \leq \pi^b(1,0) \leq \pi^b(0,0)$ is impossible. Note also that the assumption of symmetric demand and cost functions is not required for the results of this proposition.

(d) $\pi^b(1,1) < \pi^b(1,0) \leq \pi^b(0,1) < \pi^b(0,0)$

(e) $\pi^b(1,1) \leq \pi^b(0,1) < \pi^b(0,0) \leq \pi^b(1,0)$

Proof. See Appendix A. □

If each firm's strategy is to use Bertrand–Nash pricing in every pricing round following any initial investment combination (x_A, x_B), then each of Cases (a) to (e) in Proposition 1 gives rise to a reduced game in the initial investment round as shown in the corresponding case in Table 1. For example, in Case (a) of Table 1, Π_1 denotes the discounted sum of Firm A's profits conditional on $(x_A = 0, x_B = 1)$, given by $\pi^b(0,1)/(1-\delta)$ (recall that δ is the discount factor). Proposition 1 implies that in each of Cases (a) to (e) of Table 1, the payoffs satisfy $\Pi_1 \leq \Pi_2 \leq \Pi_3 \leq \Pi_4$,[6] reflecting the corresponding profit ordering in Proposition 1. In Cases (a) and (b), investing is the dominant strategy for both firms, leading to the equilibrium investment profile $(1,1)$. In particular, Case (b) is a prisoner's dilemma. In Cases (c) and (d), not investing is the dominant strategy for both firms, resulting in the equilibrium investment profile $(0,0)$. Case (e) is a game of chicken, where each pure-strategy equilibrium involves only one firm investing. Note that a stag hunt game with multiple pure strategy equilibria, corresponding to the ordering $\pi^b(0,1) \leq \pi^b(1,1) \leq \pi^b(1,0) \leq \pi^b(0,0)$, does not arise. Given the demand and marginal cost parameters, the type of reduced game changes as the additional fixed cost of CSR investment, $F(1) - F(0)$, increases, following the sequence: (a) $\rightarrow$ (b) $\rightarrow$ (e) $\rightarrow$ (c) $\rightarrow$ (d). Since the parameter range over which Case (e) arises is narrow, our experiment will focus on two more prevalent cases: (b) and (c). In Case (b), investing is the dominant strategy; in Case (c), not investing is. In the experiment to be described in Section 3, we refer to these cases as BN-INV ("Bertrand-Nash-Invest") and BN-NOINV ("Bertrand-Nash-Not-Invest"), respectively.

Second, consider potential equilibrium outcomes resulting from fully collusive pricing, or joint profit maximization, by the two firms in each pricing round, conditional on symmetric investment choices, i.e., $(x_A, x_B) = (0,0)$ or $(1,1)$. The experiment implements a sufficiently high discount factor to support collusive pricing as an equilibrium in the repeated game. Table 2 summarizes the fully collusive price p^f, quantity q^f, profits π^f, and consumer surplus v^f in each round. For comparison, it also reports the corresponding Bertrand-Nash outcomes, conditional on $(x_A, x_B) = (0,0)$ or $(1,1)$. As expected, for both $x = 0$ and $x = 1$, we have $p^b(x,x) < p^f(x,x)$, $q^b(x,x) > q^f(x,x)$, $\pi^b(x,x) < \pi^f(x,x)$, and $v^b(x,x) > v^f(x,x)$.

The Bertrand-Nash and fully collusive pricing strategies represent two polar equilibrium outcomes that can occur. In practice, actual outcomes may fall between these extremes. The extent to which investment decisions influence pricing behavior cannot be determined a priori from theory alone—especially if firms are allowed to coordinate on investment before setting prices. This is where our experiment plays a crucial role. By controlling the communication channels through which investment intentions are coordinated, we are able to investigate how information exchange affects investment decisions and subsequent pricing behavior.

[6] To be precise, some of the inequalities are strict, consistent with Proposition 1.

Table 1: Reduced Game with Bertrand-Nash Pricing

(a)

Firm A \ Firm B	$x_B = 0$	$x_B = 1$
$x_A = 0$	(Π_2, Π_2)	(Π_1, Π_4)
$x_A = 1$	(Π_4, Π_1)	$(\boldsymbol{\Pi_3, \Pi_3})$

(b)

Firm A \ Firm B	$x_B = 0$	$x_B = 1$
$x_A = 0$	(Π_3, Π_3)	(Π_1, Π_4)
$x_A = 1$	(Π_4, Π_1)	$(\boldsymbol{\Pi_2, \Pi_2})$

(c)

Firm A \ Firm B	$x_B = 0$	$x_B = 1$
$x_A = 0$	$(\boldsymbol{\Pi_4, \Pi_4})$	(Π_2, Π_3)
$x_A = 1$	(Π_3, Π_2)	(Π_1, Π_1)

(d)

Firm A \ Firm B	$x_B = 0$	$x_B = 1$
$x_A = 0$	$(\boldsymbol{\Pi_4, \Pi_4})$	(Π_3, Π_2)
$x_A = 1$	(Π_2, Π_3)	(Π_1, Π_1)

(e)

Firm A \ Firm B	$x_B = 0$	$x_B = 1$
$x_A = 0$	(Π_3, Π_3)	$(\boldsymbol{\Pi_2, \Pi_4})$
$x_A = 1$	$(\boldsymbol{\Pi_4, \Pi_2})$	(Π_1, Π_1)

Notes: In each of Cases (a) through (e), Π_1 to Π_4 represent the discounted sum of a firm's profits, conditional on the corresponding combination of x_A and x_B, and they are ordered such that $\Pi_1 \leq \Pi_2 \leq \Pi_3 \leq \Pi_4$. Payoffs shown in bold indicate Nash equilibrium profits.

Table 2: Prices, Quantities, Profits and Consumer Surplus

Bertrand-Nash	Full Collusion
$p^b(x,x) = \frac{a+b\widehat{m}(x)}{2b-c} + w(x)$	$p^f(x,x) = \frac{a}{2(b-c)} + \frac{\widehat{m}(x)}{2} + w(x)$
$q^b(x,x) = \frac{b[a-(b-c)\widehat{m}(x)]}{2b-c}$	$q^f(x,x) = \frac{a-(b-c)\widehat{m}(x)}{2}$
$\pi^b(x,x) = \frac{q^b(x,x)^2}{b} - F(x)$	$\pi^f(x,x) = \frac{q^f(x,x)^2}{(b-c)} - F(x)$
$v^b(x,x) = (\beta+\gamma)q^b(x,x)^2$	$v^f(x,x) = (\beta+\gamma)q^f(x,x)^2$

Notes: The table summarizes the Bertrand–Nash and fully collusive outcomes for each pricing round in terms of price (p), quantity (q), profit (π), and consumer surplus (v).

3 Experimental Design and Procedures

The experimental model closely follows the theoretical framework described in the previous section. Two firms in each industry first made (binary) investment decisions, which corresponded to CSR investments that affected their costs and are valued by consumers. These investments were revealed to both firms, and were followed by simultaneous price choices. The chosen price vector resulted in earnings for each firm, as determined by the relevant investment subgame.

The experiment employed a full factorial 2-by-3 experimental design, for a total of six treat-

Table 3: Numerical Parameter Values for Two Strategic Environments

Parameter	Meaning	BN-INV	BN-NOINV
β	Own-quantity inverse demand coefficient	2	2
γ	Cross-quantity inverse demand coefficient	1	1.3
α	Inverse demand intercept	15	16
$w(0)$	WTP without CSR	5	5
$w(1)$	WTP with CSR	5.5	5.5
$m(0)$	Marginal Cost without CSR	8	7.5
$m(1)$	Marginal Cost with CSR	6	6
$F(0)$	Fixed Cost without CSR	7	6
$F(1)$	Fixed Cost with CSR	13	13
	Equilibrium and Collusive Prices		
	Neither invests (Bertrand-Nash)	4	3
	Both invest (Bertrand-Nash)	2	2
	Only counterpart invests (Bertrand-Nash)	3	3
	Only self invests (Bertrand-Nash)	2	2
	Neither invests (Full Collusion)	8	8
	Both invest (Full Collusion)	6	8

Note: Equilibrium and collusive prices transformed to 1 to 8 range as displayed to subjects.

ments as preregistered at AEARCTR-0012490. All treatments were varied between subjects. The first treatment dimension varied the model payoff parameters in order to study, both quantitatively and qualitatively, differing underlying strategic environments. The following subsection provides additional details of these parameter choices. The second treatment dimension varied the communication message space available to firms before making CSR investments. The design included three different communication treatments, as explained below in Subsection 3.3.

3.1 Payoff Parameters

The experiment included two sets of model parameters in order to explore the implications of CSR investments in two distinct strategic environments. Table 3 collects these parameter values. The goal of employing different parameters was not to isolate the implications of changing exactly one variable at a time. The table indicates that four different parameter values vary simultaneously across treatments (γ, α, $m(0)$ and $F(0)$). Our goal was to contrast different strategic environments in the two parameter treatments. The treatment labeled BN-INV is an abbreviation to indicate that investment in CSR is the perfect Nash equilibrium conditional on **B**ertrand-**N**ash pricing in every subgame (case (b) of Table 1). By contrast, in the BN-NOINV treatment *not* investing in CSR is the perfect Nash equilibrium with Bertrand-Nash pricing (case (c) of Table 1).

Although the parameter differences are small, they lead to distinct investment incentives. In the BN-NOINV treatment the goods are closer substitutes, and the CSR investment in BN-NOINV raises fixed cost more but lowers marginal cost less relative to BN-INV. These differences lead to different subgame equilibrium price choices and earnings following the different investment choices for the firms. For example, if neither firm invests in BN-INV, in equilibrium each chooses a price if 12 and they earn 3.667 in profits. But if neither firm invests in BN-NOINV,

Table 4: Equilibrium Earnings for Each Subgame

	BN-INV Not Invest	BN-INV Invest		BN-NOINV Not Invest	BN-NOINV Invest
Not Invest	367, 367	175, 450	Not Invest	**441, 441**	230, 426
Invest	450, 175	**283, 283**	Invest	426, 230	159, 159

Note: Equilibrium earnings based on rounding and multiplied by 100 as displayed to subjects.

in equilibrium they choose a price of 11 and earn 4.606. Table 4 displays these equilibrium earnings for the four potential investment subgames for each treatment, after transforming units and rounding.

Subjects did not receive payoff matrices like those displayed in Table 4. Instead, following the realization of their investment choices for the upcoming rounds, their computers displayed the relevant earnings for an 8x8 matrix displaying the 64 possible price combinations; earnings were adjusted based on the previous CSR investments.[7] The instructions Appendix C displays all four of these matrices for each treatment. Thus, subjects realized the subgame equilibrium payoffs in Table 4 only if they chose Bertrand-Nash equilibrium prices.

The two payoff matrices highlight the key strategic differences motivating the parameter choices. In BN-INV, conditional on noncooperative pricing the firms have a dominant strategy to invest. This (Invest, Invest) equilibrium represents a prisoner's dilemma, however, as subjects can earn more by not investing. Not investing is the equilibrium strategy in the BN-NOINV treatment, and (as in BN-INV) it is also the joint payoff maximizing choice. In both treatments, firms could earn even more by not investing and colluding to set the highest possible price. In this case they would earn 500 each in BN-INV and 777 each in BN-NOINV.[8]

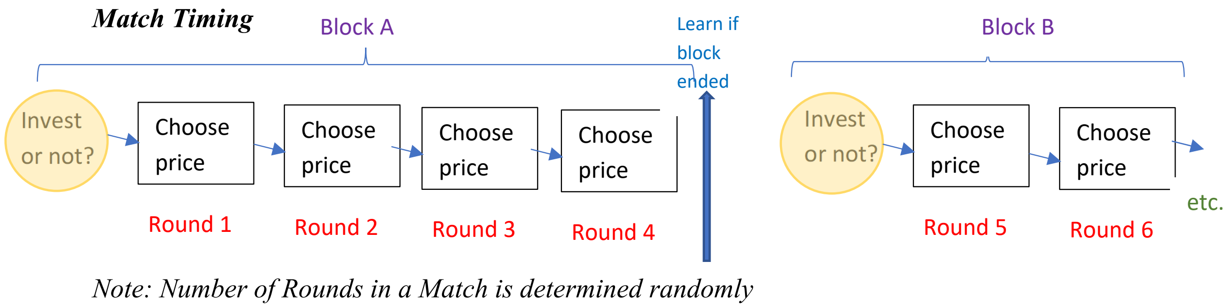
3.2 Indefinitely Repeated Supergames

The experiment sought to model the incentives of firms interacting repeatedly, as they would typically in an ongoing industry, rather than a static interaction of a one-shot game. We therefore implemented an infinitely repeated game as described in Section 2. Following standard practice in experimental economics, we implemented infinitely repeated game incentives with discounting using a random termination protocol; i.e., an indefinitely repeated game. A random draw occurred each round and the supergame (labeled a "match" for subjects) continued to the next round with 7/8 probability. This induces a stationary discount rate and the expected number of remaining periods each round is fixed at $(1-7/8)^{-1}=8$. The length of each supergame was drawn randomly in advance and the same sequence of supergame lengths was used across all sessions and treatments. This is because the length of supergames has been shown to impact behavior (Engle-Warnick and Slonim, 2006; Dal Bó and Fréchette, 2011), and by using the

[7]Prices were displayed as integers from 1 to 8 for subjects, but these actually corresponded (for the model parameters) to prices of 10.5 to 14 in 0.5 increments for BN-INV, and from 9.7 to 13.9 in 0.6 increments for BN-NOINV. The (rounded) equilibrium price in the "neither invests" subgame is thus 10.9 rather than the exact value of 11 noted in the previous paragraph. This is why the entry is 441 in Table 4 but it is 4.606 in the text.

[8]For the selected parameters, the minimum discount factor that supports full collusion in the repeated game is 0.53 and 0.50 in the BN-INV and BN-NOINV treatments, respectively. These are well below the 0.875 discount factor employed in the experiment.

Figure 1: Timeline within each Supergame Match



same pattern of lengths this influence is held constant across sessions and treatments. The 10 supergames varied in length from 1 to 19 rounds, with an average of 6.7 rounds.[9]

To avoid having initial (round 0) investment decisions locked in for the entire supergame, firms made their investment choices once every four pricing rounds. This does not impact the range of equilibrium payoffs. Figure 1 illustrates how the match timing was displayed in the instructions and explained to subjects. It also indicates that the experiment employed block random termination (Fréchette and Yuksel, 2017). This procedure ensures a minimum number of rounds for each supergame match, by only revealing whether the match randomly terminated at the conclusion of each block of four rounds. Subjects are only paid for the rounds that occurred before the termination, although they made pricing decisions for each of the four rounds while not knowing the actual termination.[10]

The experiment also introduced exogenous randomness to the investment. In particular, firms were successful in their investment 80 percent of the time, independently realized for each individual investment choice. This captures an element of realism, as one can imagine that some types of investment in CSR (such as a marketing campaign) may not succeed or be abandoned at an early stage. But a primary reason we chose this design feature is to create a set of strong instruments to allow for an instrumental variable regression strategy to assess the causal impact of investment on pricing. We elaborate on this when presenting the results in Section 4.2. At the end of each investment round, firms learned if their counterpart was successful in their investment. Given the dominant strategy incentives to invest or not invest (Table 4), this stochastic investment success does not change the Bertrand-Nash equilibrium. But due to this randomness introduced in the investment realization, often only one firm realized investment success even when both firms attempted to invest.

3.3 Communication Treatments

The experiment measured the impact of different communication opportunities between firms on their investment and pricing decisions with three treatments:

[9]The drawn lengths were 4, 19, 5, 1, 13, 1, 5, 4, 5 and 10 rounds.

[10]Due to this block random termination procedure, subjects made pricing decisions for an average of 8.8 rounds per supergame.

- **No Communication.** Baseline condition with no communication opportunities across firms. They only observe the previous price choices and realized investment success of the other firm in their industry.

- **Restrictive Communication.** Firms send a binary, cheap talk message to the other firm immediately before each investment decision, indicating "whether or not they intend to invest for the upcoming rounds." These intentions are shared across both firms before they make their simultaneous and binding investment choice that applies for the following rounds. The instructions emphasize that they are free to choose whether or not to invest regardless of what is communicated.

- **Rich Communication.** Firms can engage in a free form (text) bilateral chat with the other firm in their industry, prior to each investment decision. They are not restricted in what they communicate about; in particular, they can discuss subsequent pricing as well as the upcoming investment decisions.[11] The chat is open for two minutes at the start of each supergame match, and for one minute before each later investment decision (which occurs every four rounds) within an ongoing supergame.

These manipulations of the communication message space can be thought of as different levels of competition/antitrust authority scrutiny of potential agreements between firms to collaborate on CSR investments. The binary message in the restrictive communication treatment is a minimal step to help firms coordinate their investments, but without the opportunity to discuss (illegally) prices. Price-fixing can (and is) discussed only in the rich communication treatment.[12]

3.4 Laboratory Procedures

We collected data from a total of 248 subjects in 16 independent matching groups. All subjects were in the role of sellers, and buyers were simulated by the computer. Utility functions, demand curves, and consumer surplus shifted with the CSR investments. As explained above in Subsection 3.2, subjects completed ten supergames of varying lengths. They were randomly reassigned to new duopoly industries at the start of each supergame, out of matching groups of 12 to 18 subjects. A total of 46 subjects participated in each of the four treatments with no communication or restrictive communication. The design included fewer subjects (32 each) for the two treatments with rich communication because preliminary sessions indicated considerably lower investment and price variance with rich communication.

[11] Chat communication is frequently used in experiments because it is nearly as rich as verbal communication, but it is easier to maintain anonymity and record exactly what is communicated. Subjects are told that the experimenters "record the messages that are sent." They also "request that you follow two simple rules: (1) Be civil to each other and use no profanity, and (2) Do not identify yourself by name or number or gender or appearance, or in any other way."

[12] Rather than limiting communication opportunities, an alternative way to vary regulatory enforcement would be to monitor communication or price levels–perhaps probabilistically. Stronger enforcement could correspond to greater inspection likelihood, for example, or a human participant who takes the role of a competition authority and may monitor discussions as in Andres et al. (2023). We chose to not introduce enforcement in such ways to avoid defining to subjects exactly what would be considered illegal communication, since different individuals may exhibit different susceptibility to experimenter demand effects.

The subjects were all undergraduate students at Purdue University, recruited from a database of approximately 5,000 volunteers drawn across a wide range of academic disciplines and randomly allocated to the six treatment conditions using ORSEE (Greiner, 2015). The experiment was implemented using oTree (Chen et al., 2016). We used framing that referred to "investment" in the first stage, but no reference to the purpose of the investment other than to affect the earnings in the pricing subgames.[13] In the second stage of each round, following revelation of the investment success for each firm, subjects chose a price scaled from the integers 1 through 8. Their hardcopy instructions included the payoff matrices for all four investment subgames, corresponding to both investing, neither investing, or one firm investing; the computer software displayed the specific relevant payoff matrix conditional on actual investments for the current round. The other firm in a subject's "industry" was framed neutrally as their "counterpart" to avoid competitive or cooperative framing. Details are provided in the instructions given to subjects (see the online instructions Appendix C).

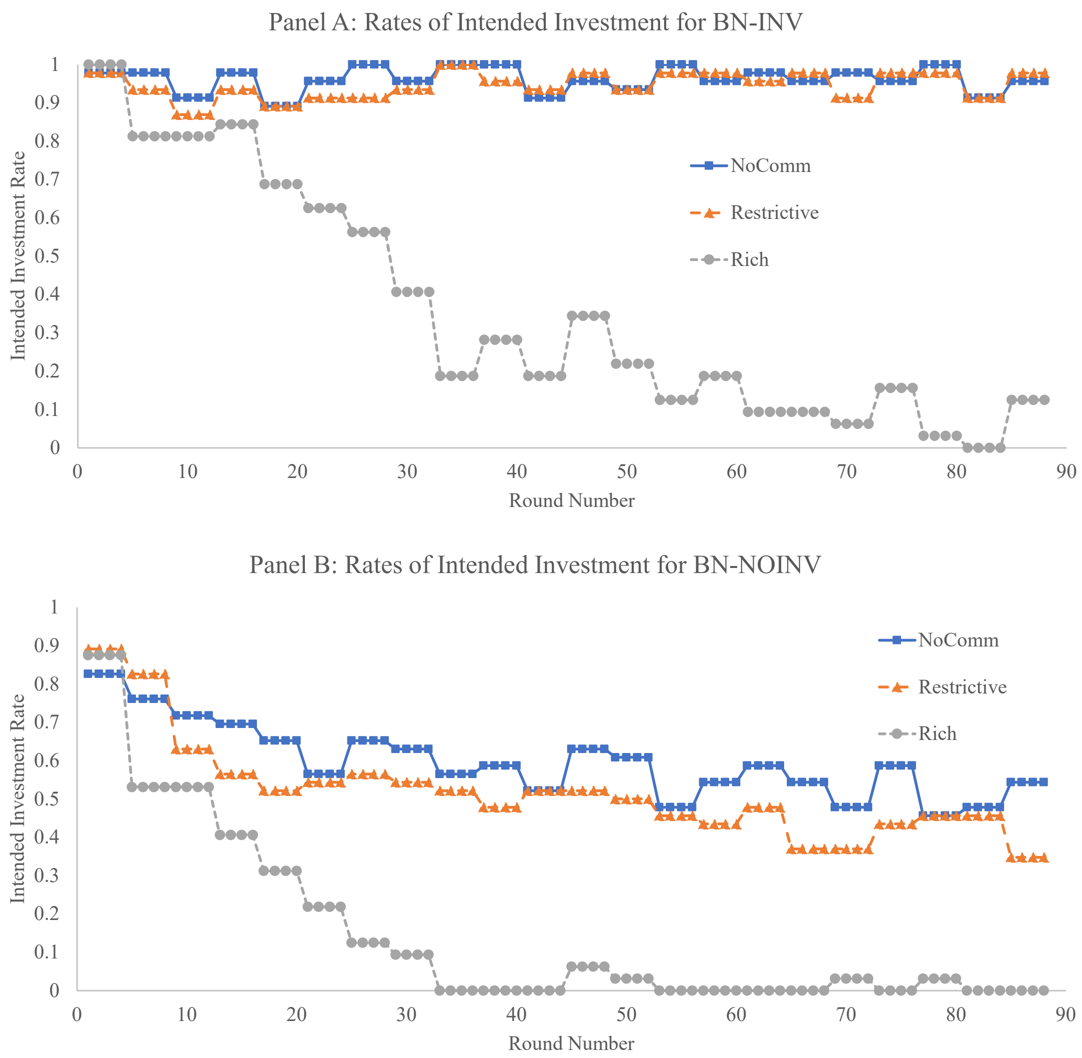
A computerized voice read these written instructions aloud at the start of the session, while subjects could follow along on their own hardcopy. This was accompanied by summary points and graphics projected on the lab projection screen in order to promote common knowledge about all of the aspects of the experimental design. Subjects then completed a six-question comprehension quiz to reinforce key aspects of the instructions, earning $1 for each correct answer. Each session concluded with a short measurement of risk preferences using the Eckel and Grossman (2008) risk task, and a short Social Value Orientation task, implemented with 6 allocation choices (Murphy et al., 2011), with one choice in each pair randomly drawn for payment (see Parts 2 and 3 of the instructions Appendix C). Sessions lasted about 75 to 95 minutes each, including instructions and payment time. At the conclusion of each session earnings were paid privately in cash. Subjects earned $27.00 on average per person, with an interquartile range [$23.75, $30.25].

4 Results

We present the results in five subsections. Subsection 4.1 compares firms' investment rates across treatments. Subsection 4.2 examines their price choices, and how prices differ between investment subgames. Subsection 4.3 reports firm earnings to further document price collusion, and Subsection 4.4 briefly summarizes the messages and how they impact investment choices in the restrictive communication treatment. Subsection 4.5 reports consumer surplus. Each of the 248 subjects made 88 pricing decisions, so our panel dataset has 21,824 individual price choices. They made investment decisions every four rounds, for a total of 5,456 individual investment choices.

[13]The instructions stated: "Your investment affects your costs, and it also influences how much the computerized buyers are willing to pay for your product. The combination of costs and buyers' purchase demand determines your earnings."

Figure 2: Time Series of Intended Investment for All Six Treatments



4.1 CSR Investments

Figure 2 displays the time series of firms' "intended" investment frequency for all six treatments across the 88 rounds. (Recall that investment succeeded by design only 80 percent of the time.) These rates are always constant for 4 consecutive rounds because firms make their investment decision once every four rounds. Investment rates are very high and are similar in all treatments for the initial rounds. In the rich communication treatment, however, investment rates decline quickly and eventually fall towards zero–more quickly in the BN-NOINV payoff parameters where not investing is an equilibrium of the static game (Panel B). Investment rates also decline over time in the other two communication treatments for the BN-NOINV parameters, but at a much slower rate. By contrast, investment rates remain high in the no communication and restrictive communication treatments with the BN-INV parameters where investment is an equilibrium (Panel A).

Tables 5 and 6 report panel regressions to compare the intended investment rates statistically, and support our first empirical result. These regressions account for time trends with a round number regressor and interactions, and also include demographic and estimated risk and social preference controls.[14]

Result 1: Intended investment rates are significantly lower in the rich communication treatment than the other two communication treatments, and are higher in all three communication treatments for the BN-INV parameters where investment is consistent with a Bertrand-Nash equilibrium. Restrictive communication does not significantly impact investment relative to no communication for either set of payoff parameters.

Support: The top row of Table 5 supports the final part of this investment result statement. The ommited case for the regressions in this table is the no communication baseline, and the restrictive communication dummy variable is never statistically significant. By contrast, the rich communication dummy variable is always negative and significant, and the interaction with the round number indicates that the investment decline is faster in this treatment as well–as illustrated already in Figure 2. Models 2 and 4 of this table omit the first four supergames (rounds 1-36) where the intial time trend is most pronounced. The coefficient estimates indicate that the investment rates with rich communication are a small fraction of the rates for the other two communication treatments in the later rounds. The first row of Table 6 indicates that, relative to the omitted BN-NOINV case, investment rates are greater in BN-INV for all 3 communication treatments; and the treatment interaction with the decision round indicates that these differences are increasing over time with restrictive or no communication.

One puzzle in Panel B of Figure 2 is the slow rate of decline in intended investment rates in the BN-NOINV condition with no or with restrictive communication. Investment rates in these cases decline initially, but appear to level out by round 50 or so, while still drifting down slightly. Perhaps they would settle significantly closer to the equilibrium investment rate of zero in a much longer experiment.

To test this conjecture we fit a model of long-term asymptotic behavior of the investment time series. Results suggest that the long-run investment rate in these conditions stays well above zero. The model, used previously by Noussair et al. (1995), Cason and Noussair (2007) and others, assumes that the investment rate exhibits a convergence pattern over time within each experimental session and approaches a common value asympototically. In particular, we estimated the following model for these two treatments separately:

$$y_{it} = \beta_{11}D_1(1/t) + \beta_{12}D_2(1/t) + ... + \beta_{1k}D_k(1/t) + \beta_2\frac{t-1}{t} + u_{it}, \tag{6}$$

where y_{it} is the mean intended investment rate in session i in round t, $i = 1, ...k$ indexes the session, and the D_i dummy variables take on a value of 1 for the indicated session within each treatment. Note that in the first round $t = 1$, so the $(t-1)/t$ term is zero. Thus the β_{1i} coefficient provides an estimate of the value of the dependent variable (mean investment) at the beginning of session i. As $t \to \infty$ the $1/t$ terms approach zero whereas the $(t-1)/t$ term approaches one. Therefore the β_2 coefficient indicates the asymptotic level of investment for the treatment condition.

[14]Demographic control variables include gender, race and college standing (1st or 2nd year versus upperclassmen).

Table 5: Intended Investment Choices – Comparing Communication Treatments

Linear Probability Model Variable:	Model 1 BN-INV	Model 2 Late BN-INV	Model 3 BN-NOINV	Model 4 Late BN-NOINV
Restrictive comm. (dummy)	-0.011	-0.001	-0.075	-0.094
	(0.026)	(0.029)	(0.059)	(0.067)
Rich comm. (dummy)	-0.114***	-0.805***	-0.292***	-0.526***
	(0.034)	(0.032)	(0.070)	(0.074)
Round in session	0.000		-0.004***	
	(0.000)		(0.000)	
Rich comm*Round	-0.011***		-0.004***	
(interaction)	(0.000)		(0.001)	
Constant	0.996***	0.988***	0.858***	0.656***
	(0.038)	(0.039)	(0.077)	(0.086)
Demographic and preference controls	Yes	Yes	Yes	Yes
R-squared	0.558	0.681	0.226	0.233
Observations	2,728	1,612	2,728	1,612
Number of subjects	124	124	124	124

Note: Standard errors in parentheses based on subject random effects. Late matches (Models 2 and 4) include final 6 out of 10 matches only. ***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

Table 6: Intended Investment Choices – Comparing Parameterization Treatments

Linear Probability Model Variable:	Model 1 No Comm	Model 2 Restr. Comm	Model 3 Rich Comm
BN-INV (dummy)	0.237***	0.232***	0.368***
	(0.058)	(0.052)	(0.048)
Round in session	-0.003***	-0.004***	-0.007***
	(0.000)	(0.000)	(0.000)
BN-INV*Round	0.003***	0.005***	-0.004***
(interaction)	(0.000)	(0.001)	(0.001)
Constant	0.844***	0.727***	0.572***
	(0.087)	(0.064)	(0.062)
Demographic and preference controls	Yes	Yes	Yes
R-squared	0.232	0.285	0.378
Observations	2,024	2,024	1,408
Number of subjects	92	92	64

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

Estimates of this model (not shown) indicate that the estimated asymptote (β_2) for mean intended investment is 0.539 (s.e.=0.024) for the BN-NOINV treatment without communication, and is 0.415 (s.e.=0.024) in the BN-NOINV treatment with restrictive communication. This indicates that the investment frequency appears to level off and may not continue towards zero in much longer sessions. So why is there a slow decline in the investment rate in the BN-NOINV treatment, even though not investing is a dominant strategy conditional on competitive (Bertrand-Nash) pricing? Note that not investing is also part of an optimally collusive strategy.

Given the estimated investment rate with restrictive or no communication ranges above 40 percent even in the long run for the BN-NOINV parameters, firms often faced the asymmetric subgame where only one firm invested. This leads to considerable payoff inequality, which could increase the relevance of social preferences. Strong evidence exists that many people are averse to inequality (i.e., receiving payoffs lower or higher than others), as modeled by Fehr and Schmidt (1999) and others. Table 4 shows that, conditional on Bertrand-Nash pricing, if a firm deviates from the {Not Invest, Not Invest} strategy combination and invests, this lowers their own earnings slightly (from 441 to 426) but it lowers their rival firms' earnings substantially (from 441 to 230).

The payoff inequality arising from asymmetric investment choices might cause some subjects who have pro-social preferences to invest at a lower rate than subjects who have individualistic (own-payoff-maximizing) preferences. For example, a pro-social individual suffers disutility if their counterpart earns a lot less than they earn themselves, so they may not invest to avoid this outcome. An individualistic individual does not face this extra disutility when investing.[15] Our design allows us to quantify the role of outcome-based social preferences because the conclusion of each session included a Social Value Orientation task. All 248 subjects made six monetary allocations in this task. It separates them into 116 who are individualistic because they largely chose allocations that give themselves the greatest amount, and 131 others that exhibit prosocial preferences because they often sacrificed some of their own payoffs when this can benefit someone else.[16]

The main regression results in Tables 5 and 6 include controls for these social preference differences across subjects, as well as their risk aversion and demographics. Those tables do not display the estimates for these controls for brevity. Table B-1 in the appendix presents some similar regressions for investment, displaying the demographic and preference controls' coefficient estimates. Note in the Table B-1 investment regression that for the BN-NOINV condition (Model 2) the dummy variable identifying pro-social subjects is negative and highly significant. This indicates that pro-social individuals were less likely to invest than those with selfish, individualistic preferences, consistent with the discussion in the previous paragraph.[17]

[15] Note that this difference in motivations between those with own-payoff-maximizing preferences and those with pro-social preferences is not present in the BN-INV condition, since investing increases a firm's own payoffs and both firms invested in most rounds (Figure 2) which reduced payoff inequality.

[16] One final subject is classified as competitive because he chose allocations that maximized the positive difference between his own earnings and the other's earnings.

[17] These regressions also include lagged investment and price choices for the subject and their counterpart, to capture "behavioral" responses to others' past actions. Estimates indicate that subjects invest significantly more often when they or their counterpart successfully invested in the previous opportunity. They are also less likely to invest following rounds where they selected higher prices. Men and non-white subjects also tended to invest less often.

4.2 Pricing

The realized investment outcomes determined which pricing subgame applied for each subsequent four rounds. As just documented, in the treatments with rich communication firms rarely invested, especially in the later rounds of their session. Therefore, in the later supergames only the subgame with neither firm investing provides a meaningful amount of data to analyze. In the treatments without rich communication, we can investigate subgames with and without successful investment. Even in the BN-INV treatment with restrictive or no communication, where intended investment is overwhelmingly common, since investment success is stochastic the data provide considerable observations without investment success. When both firms attempt to invest, however, they *both* fail with only 4 percent likelihood. So the "neither invests" subgame is realized infrequently in these treatments.

Figure 3 displays the mean price choices across treatments for all four possible subgames. This figure pools across all 88 rounds (21,824 price choices), since the time trend across rounds either within supergames or across supergames is weak. The figure shades in a lighter color the means that are based on a small (less than 300) number of observations. Prices are displayed based on the transformed 1 to 8 price range as viewed by firms.

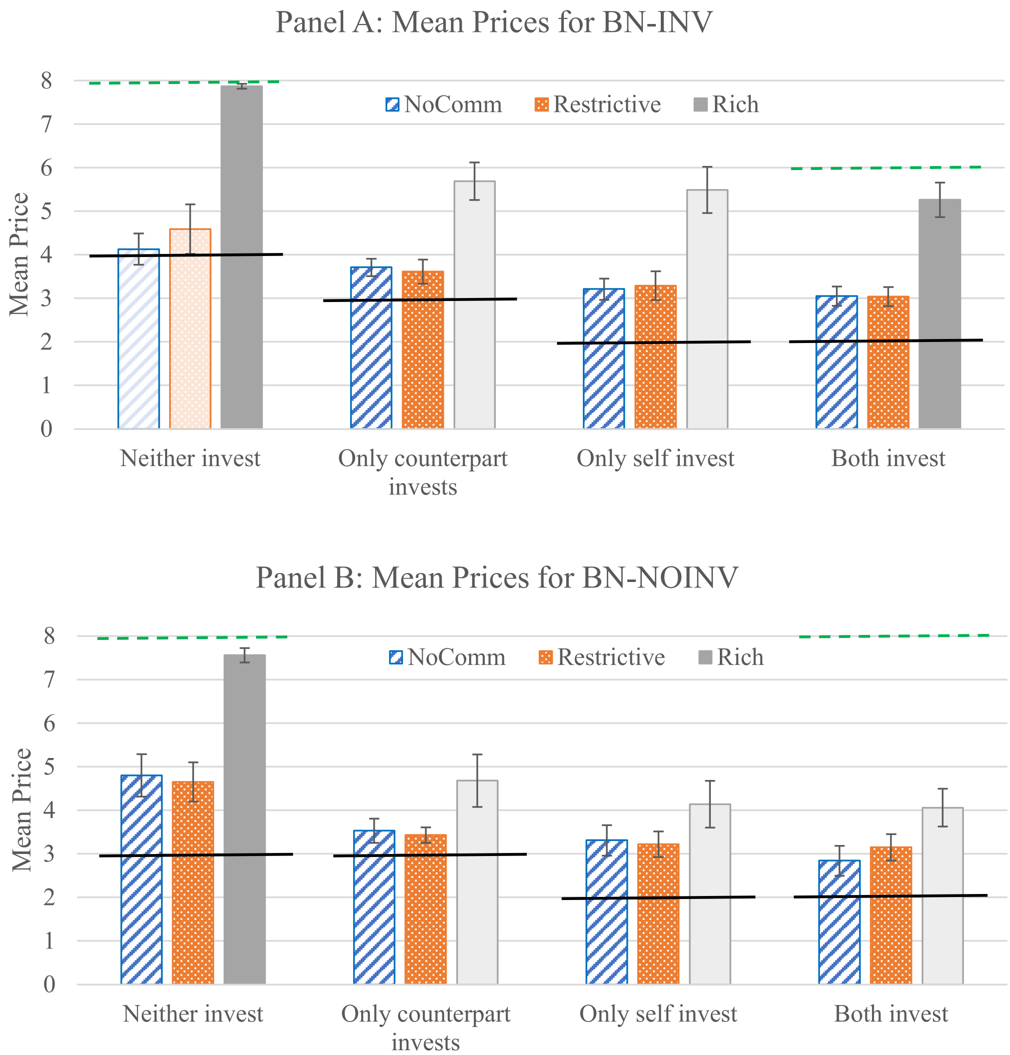
Several clear patterns emerge from inspection of these mean prices. First, prices are greater on average with rich communication, across all subgames for both payoff parameters. They are also near the maximum (8) in the most frequently-played "neither invests" subgame, which is also the joint payoff maximizing price for both payoff parameters. The joint payoff maximizing price conditional on both firms investing for the BN-INV parameters is 6, and observed mean (5.26) is not far below this level (far right, Panel A). Thus, it is clear in the pricing data that firms were quite successful in implementing collusive pricing as well as investment agreements when rich communication was permitted.

Without rich communication, prices were lower but on average they modestly exceed the static game Bertrand-Nash equilibrium. This noncooperative theoretical benchmark is 2 when both firms invest for both payoff parameters, while mean prices are near 3 in the restrictive and no communication treatments. The Bertrand-Nash prices in the subgame where neither invests is 4 for the BN-INV parameters and 3 for the BN-NOINV parameters, while mean prices range between 4 and 5. Finally, for the asymmetric subgames with only one firm successfully investing, in all three communication treatments the mean price appears a bit higher when the other ("counterpart") invests than when only the firm itself is the only investor. A price of 2 for the investor and 3 for the non-investor is the static Bertrand-Nash equilibrium for both payoff parameters.

As with the investment decisions considered in the previous subsection, we use panel regressions with controls for time trends, demographics and risk/social preferences to document statistical differences across treatments.

Result 2: For all treatment conditions and investment subgames, firms choose significantly higher prices when they have rich communication opportunities relative to restrictive or no communication. They also choose systematically and significantly higher prices when *not* investing in CSR in the BN-INV parameter case.

Figure 3: Mean Prices for all Treatments and Investment Subgames (all rounds)



Note: Solid black lines denote the static game Bertrand-Nash equilibrium, dashed green lines denote joint profit maximizing prices. Error bars designate 95% confidence intervals based on clustered standard errors.

Support: Table 7 reports random effects regressions that document the treatment effects of the communication opportunity treatments on price choices, separately for the four potential investment combination subgames. In all 8 models, which cover both payoff parameters, the rich Communication dummy variable is significantly positive. This indicates higher prices relative to the no communication baseline. The restrictive communication treatment is only significant in one case, Model 1 for the neither invest subgame for the BN-INV parameters.[18] Consistent with Figure 3, prices differ little when only restrictive communication opportunities are made available.

Firms collude effectively in this experiment when they have the opportunity for an inter-

[18]Note that this neither invests subgame is rarely played for the BN-INV parameters with restrictive or no communication, since in these conditions firms attempted to invest more than 90 percent of the time (Figure 2).

active chat in the rich communication treatment. Recall that the communication opportunity arose every four rounds, immediately before they made their investment decision. The only restriction imposed on their communications were requirements to be civil to each other and to not identify themselves. Although in their chats the subjects often discussed their upcoming investment decisions, they also recognized the benefit of discussing prices. Interestingly, some of the chats also include clear threats of potential retaliation to punish deviations from their collusive agreement. Tables B-4 and B-5 in the appendix contain illustrative chat dialogs for four representative examples.

Not surprisingly, firms require one or two supergames to recognize and learn to implement a collusive agreement in the rich communication treatment. As mentioned in footnote 7, the first and second supergames lasted 4 and 19 rounds, respectively. After reaching the third supergame, featured in the example chats, their collusion was largely successful. Price choices mostly "lock on" and stay at the maximum and optimal collusive level (8) throughout the remainder of the session in the subgame where neither firm invests. This is especially true for the BN-INV treatment, where the average price for this subgame is 7.93 for the final seven supergames. Prices are less reliably fixed on 8 in the BN-NOINV treatment, and their average is lower (7.61) during these same supergames when neither firm invests.

Table 8 reports random effects regressions to support the second part of Result 2. A complication that arises when trying to draw causal inferences between investment and pricing is that obviously the investment choice is endogenous. As mentioned in the experimental design section, one of the main motivations of making investment success stochastic was to create strong instruments by design that exogenously influence which investment subgame is realized. To implement the imperfect investment success, in every investment round for every firm an integer was randomly drawn, uniformly distributed between 1 and 100. A firm successfully invested if they choose to attempt investment *and* this integer draw was greater than 20. This creates two random variables (the realized draw in the current round for each member of the duopoly pair) that are entirely exogenous and strongly correlated with the realized investment subgame. In other words, the design creates strong instruments that we use in an IV estimation to obviate the concerns about the endogeneity of investment.[19]

The instrumental variables regressions in Table 8 show that successful investment typically leads to lower prices. This is consistent with Figure 3, as well as simple intuition since investment lowers marginal costs in our model. This difference is usually significant with the BN-INV payoff parameters, except in Model 6 where the asymmetric subgames with only one successful investor occur infrequently with rich communication. The differences are generally smaller and are not statistically significant for the BN-NOINV parameters, except for the rich communication comparison between the subgames with both versus neither firm investing (Model 9).

[19]Unlike applications with field data where the researcher needs to assert that the instruments are uncorrelated with the error terms, in the lab independence is automatically satisfied since they are uncorrelated by construction. Previous applications of this type of IV strategy in lab experiments include Ham et al. (2005), Casari et al. (2007), Costa-Gomes et al. (2012), Gill and Prowse (2014) and Ham and Lehrer (2020). In our case the instruments are all strong, with F-statistics ranging from 30 to 1369 across the 12 models in Table 8–all far above the rule-of-thumb threshold of Staiger and Stock (1997).

Table 7: Price Choices by Investment Subgame – Comparing Communication Treatments

Panel A: BN-INV Parameters	Model 1 Neither Invest	Model 2 Only Counterpart	Model 3 Only Self Invest	Model 4 Both Invest
Restrictive comm.	0.559**	-0.216	0.131	0.032
(dummy)	(0.253)	(0.182)	(0.200)	(0.174)
Rich comm.	2.950***	1.975***	2.287***	1.850***
(dummy)	(0.268)	(0.272)	(0.308)	(0.211)
Round in session	-0.009***	-0.002*	0.003**	0.003***
	(0.002)	(0.001)	(0.001)	(0.001)
Rich comm*Round	0.014***	-0.002	0.002	0.023***
(interaction)	(0.002)	(0.005)	(0.005)	(0.003)
Constant	4.876***	3.413***	3.138***	2.704***
	(0.338)	(0.264)	(0.297)	(0.247)
Demographic and preference controls	Yes	Yes	Yes	Yes
R-squared	0.734	0.211	0.207	0.219
Observations	2,280	1,684	1,684	5,264
Number of subjects	101	118	111	123

Panel B: BN-NOINV Parameters	Model 5 Neither Invest	Model 6 Only Counterpart	Model 7 Only Self Invest	Model 8 Both Invest
Restrictive comm.	-0.107	0.163	-0.108	0.127
(dummy)	(0.239)	(0.228)	(0.222)	(0.216)
Rich comm.	3.333***	1.383***	0.889**	1.103***
(dummy)	(0.269)	(0.405)	(0.355)	(0.279)
Round in session	0.011***	0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)
Rich comm*Round	-0.005***	-0.008	0.002	0.004
(interaction)	(0.002)	(0.015)	(0.011)	(0.011)
Constant	4.027***	3.638***	3.575***	3.071***
	(0.309)	(0.308)	(0.305)	(0.286)
Demographic and preference controls	Yes	Yes	Yes	Yes
R-squared	0.452	0.045	0.027	0.069
Observations	5,000	2,032	2,032	1,848
Number of subjects	121	113	100	116

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

4.3 Firm Earnings

Figure 4 reports average earnings for the different CSR investment subgames, along with Bertrand-Nash equilibrium and (for the symmetric subgames) the joint payoff maximizing earnings. Earnings correspond roughly to the static equilibrium predictions in the BN-INV parameter configuration when firms have restrictive or no communication opportunities. They earn modestly

Table 8: Price Choices by Investment Success – Symmetric and Asymmetric Subgames

	Both vs. Neither Succeed			One Successful Investment		
Panel A: BN-INV Parameters	Model 1 No Comm.	Model 2 Restrictive	Model 3 Rich	Model 4 No Comm.	Model 5 Restrictive	Model 6 Rich
Successful Invest	-1.247***	-1.362***	-0.927**	-0.531***	-0.346***	-0.047
(Instrumented)	(0.127)	(0.191)	(0.412)	(0.079)	(0.090)	(0.197)
Round in session	0.001	0.003***	0.021***	0.002*	-0.003**	0.001
	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.004)
Constant	4.433***	3.732***	6.221***	3.616***	3.300***	5.572***
	(0.365)	(0.394)	(0.387)	(0.310)	(0.379)	(0.592)
Demographic and preference controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.120	0.124	0.484	0.058	0.069	0.113
Observations	2,584	2,576	2,384	1,464	1,472	432
Number of subjects	46	46	32	46	46	30

	Both vs. Neither Succeed			One Successful Investment		
Panel B: BN-NOINV Parameters	Model 7 No Comm.	Model 8 Restrictive	Model 9 Rich	Model 10 No Comm.	Model 11 Restrictive	Model 12 Rich
Successful Invest	-0.125	-0.378	-3.696***	-0.116	0.006	-0.595
(Instrumented)	(0.214)	(0.270)	(0.672)	(0.158)	(0.143)	(0.430)
Round in session	0.013***	0.010***	0.003	-0.003**	0.003**	-0.001
	(0.002)	(0.002)	(0.004)	(0.001)	(0.001)	(0.011)
Constant	3.031***	4.227***	7.490***	3.715***	3.416***	5.174***
	(0.468)	(0.458)	(0.380)	(0.337)	(0.294)	(0.848)
Demographic and preference controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.230	0.144	0.367	0.060	0.005	0.045
Observations	2,000	2,240	2,608	2,048	1,808	208
Number of subjects	46	46	32	46	46	28

Note: Standard errors in parentheses based on subject random effects. Investment success instrumented using realized stochastic success draws. ***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

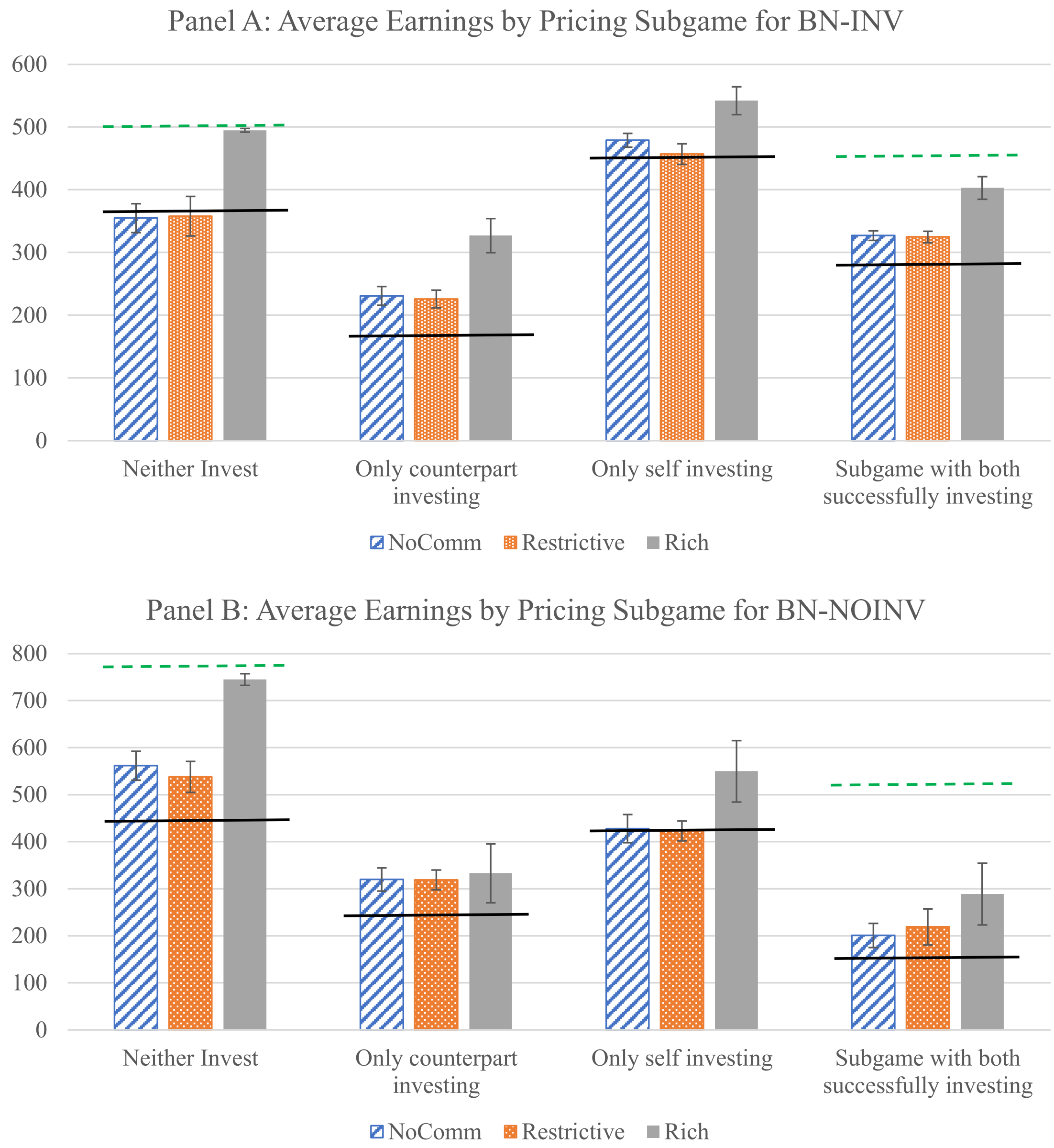
supercompetitive profits when investing in CSR for this parameter set. By contrast, firms earn profits well above the noncooperative equilibrium level in three of the four investment subgames for the BN-NOINV parameters.

The other clear pattern that emerges from inspecting this figure is the higher profits arising from rich communication, which is the finding summarized in our next formal result.

Result 3: For nearly all treatment conditions and investment subgames, firms earn significantly greater profits when they have rich communication opportunities relative to restrictive or no communication.

Support: Table 9 displays random effects regressions of individual earnings, separately for

Figure 4: Average Earnings for all Treatments and Investment Subgames (all rounds)



Note: Solid black lines denote Bertrand-Nash equilibrium earnings, and dashed green lines denote joint profit maximizing earnings. Error bars designate 95% confidence intervals based on clustered standard errors.

each investment subgame, with dummy variables for the communication treatments. As in the previous panel regressions, the models control for time trends and demographic and individual risk and social preferences. Similar to the (lack of) price differences, earnings are generally not different when adding restrictive communication opportunities. The lone exception is a marginal difference for Model 3. In contrast, for 7 of the 8 models adding rich communication significantly increases earnings, and by a substantial margin ranging between 73 and 228 experimental currency units. This is roughly 20 to 50 percent of per-round earnings. The time trends also indicate increasing earnings in some cases, such as with rich communication and neither investing

Table 9: Firm Earnings by Investment Subgame – Comparing Communication Treatments

Panel A: BN-INV Parameters	Model 1 Neither Invest	Model 2 Only Counterpart	Model 3 Only Self Invest	Model 4 Both Invest
Restrictive comm.	11.251	-4.194	-21.225*	-1.897
(dummy)	(17.523)	(11.479)	(11.193)	(7.356)
Rich comm.	102.691***	106.229***	93.043***	73.336***
(dummy)	(18.833)	(18.802)	(21.902)	(11.568)
Round in session	-0.672***	0.162	-0.139	0.154**
	(0.150)	(0.107)	(0.136)	(0.075)
Rich comm*Round	0.853***	-0.413	-1.266***	0.371
(interaction)	(0.163)	(0.362)	(0.484)	(0.310)
Constant	390.601***	233.477***	510.534***	326.620***
	(23.445)	(17.056)	(17.841)	(11.020)
Demographic and preference controls	Yes	Yes	Yes	Yes
R-squared	0.418	0.100	0.052	0.036
Observations	2,280	1,684	1,684	5,264
Number of subjects	101	118	111	123

Panel B: BN-NOINV Parameters	Model 5 Neither Invest	Model 6 Only Counterpart	Model 7 Only Self Invest	Model 8 Both Invest
Restrictive comm.	-23.212	8.167	-3.149	17.234
(dummy)	(19.231)	(19.908)	(21.104)	(25.217)
Rich comm.	228.361***	18.026	156.883***	87.194**
(dummy)	(23.224)	(41.351)	(45.007)	(38.880)
Round in session	0.904***	-0.199	0.386	-0.001
	(0.162)	(0.191)	(0.236)	(0.292)
Rich comm*Round	-0.597**	0.329	-1.530	1.448
(interaction)	(0.235)	(1.654)	(1.792)	(2.052)
Constant	484.701***	313.767***	416.660***	152.720***
	(25.492)	(28.306)	(30.334)	(34.877)
Demographic and preference controls	Yes	Yes	Yes	Yes
R-squared	0.208	0.003	0.019	0.010
Observations	5,000	2,032	2,032	1,848
Number of subjects	121	113	100	116

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

in BN-INV (Model 1), and without rich communication and both investing in BN-INV (Model 4) or neither investing in BN-NOINV (Model 5).

Our experimental design uses firm earnings from Bertrand-Nash pricing each round (Table 4) as the benchmark to derive noncooperative investment incentives. Noncooperative pricing leads investment to be a dominant strategy for the BN-INV parameters, while not investing is

Table 10: Mean Realized Earnings for Each Subgame, for Final 5 (of 10) Supergames

No Communication BN-INV

	Not Invest	Invest
Not Invest	341, 341	238, 472
Invest	472, 238	332, 332

No Communication BN-NOINV

	Not Invest	Invest
Not Invest	583, 583	308, 417
Invest	417, 308	201, 201

Restrictive Communication BN-INV

	Not Invest	Invest
Not Invest	355, 355	226, 453
Invest	453, 226	333, 333

Restrictive Communication BN-NOINV

	Not Invest	Invest
Not Invest	556, 556	318, 452
Invest	452, 318	215, 215

Rich Communication BN-INV

	Not Invest	Invest
Not Invest	497, 497	312, 512
Invest	512, 312	408, 408

Rich Communication BN-NOINV

	Not Invest	Invest
Not Invest	758, 758	
Invest		

Note: Invest cells in the rich communication case are based on few observations. (So few in BN-NOINV that the means are omitted for the BN-NOINV case).

a dominant strategy for the BN-NOINV parameters. Table 10 reports realized mean earnings for the investment subgames in each treatment during the last half of the supergames. Average payoffs generally exceed Bertand-Nash levels shown in Table 4, except sometimes for the BN-INV parameters with no or restrictive communication, as already documented for all rounds in Figure 4. Nevertheless, the ordering of actual average payoffs corresponds to the dominant strategy ordering summarized above: Investment always leads to higher mean payoffs than not investing in the BN-INV condition, and not investing leads to greater mean payoffs than investing for the BN-NOINV condition. This is consistent with the earlier support for the model's prediction that investment is greater for the BN-INV than the BN-NOINV parameters (Result 1).

4.4 Is Restrictive Communication Cheap Talk?

The previous subsections document that investment rates, prices and firm earnings differ little between the no communication baseline and the restrictive communication treatment. Recall that in the restrictive communication case firms could send a binary message indicating whether or not they intended to invest for the upcoming rounds. Since this communication had little measurable impact on behavior or performance, it raises the natural question of whether the shared communication was simply cheap talk to be ignored.

An examination of the binary messages exchanged and the subsequent investment decisions reveals, however, that firms frequently made investment decisions that corresponded to their messages. This indicates that the communication conveyed information to help coordinate investment decisions. Moreover, firms reacted to the message exchanged by their counterpart.

Table 11 documents this finding with some simple frequency counts. It reports results for

Table 11: Messages and Actual Intended Investment: Restrictive Comm., BN-NOINV Treatment

	Actual Investment Choices			
Message(s) Sent	Not Invest	Invest	(Invest Rate)	Total
Communicates Not Investment	412	124	(0.231)	536
Communicates Investment	74	402	(0.845)	476
Both Firms Communicate Not Invest	270	58	(0.177)	328
Only Counterpart Communicates Invest	142	66	(0.317)	208
Only Self Communicates Invest	42	166	(0.798)	208
Both Firms Communicate Invest	32	236	(0.881)	268

only the BN-NOINV treatment, since (as already documented in Subsection 4.1) investment was nearly universal in the BN-INV treatment. In the BN-INV treatment firms also usually sent a message that they intended to invest.[20]

For the BN-NOINV treatment, firms tried to invest about half the time. The top part of Table 11 shows that they were much more likely to invest (rate of 0.845) when they sent a message indicating this intention, than when not indicating an intention to invest (where the rate is only 0.231). The lower rows of this table also show that firms respond to the message communicated by their counterpart. In particular, if their counterpart indicates an intention to invest, conditional on sharing a non-investment message themselves, this increases the actual investment rate from 0.177 to 0.317. Similarly, they are more likely to follow through on their investment message if their counterpart also sends an investment message (0.881) than when the counterpart sends a not invest message (0.798).

4.5 Consumer Surplus

The CSR investments and firm price choices have direct implications for consumer surplus. As discussed in Appendix A, whether consumer surplus increases after investment depends on whether price increases more or less than the representative consumer's additional willingness to pay due to the investment. In light of the significantly greater profits earned by firms when they have rich communication opportunities, not surprisingly this rich communication has clear negative implications for consumer surplus.

Result 4: Consumer surplus is significantly lower when firms have rich communication opportunities relative to restrictive or no communication.

Support: Table 12 displays random effects regressions of realized consumer surplus, separately for each investment subgame, with dummy variables for the communication treatments. As in the previous regressions, the estimates control for time trends; they do not include demographic controls, however, because market outcomes and surplus depend on pairs of sellers who are randomly re-matched for each new supergame. Consumer surplus does not differ between the no communication baseline and the restrictive communication treatment, similar to the earlier results regarding prices and firm profits. Adding rich communication, however, significantly

[20]Specifically, they sent a message of intended investment 86 percent of the time, and actually invested 98 percent of the time they sent this message and 95 percent of the time overall.

Table 12: Consumer Surplus by Investment Success – Comparing Communication Treatments

	EQ-INV Parameters			EQ-NOINV Parameters		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable:	None Invest	One Invests	Both Invest	None Invest	One Invests	Both Invest
Restrictive comm.	-89.35	15.56	4.29	44.33	29.92	-99.75
(dummy)	(74.84)	(48.60)	(49.28)	(80.35)	(64.80)	(80.28)
Rich comm.	-549.90***	-609.53***	-476.74***	-1,007.95***	-484.74***	-468.99***
(dummy)	(77.11)	(72.08)	(67.80)	(92.68)	(108.54)	(113.30)
Round in session	5.79***	-0.66**	-0.89***	-3.60***	-0.13	-0.42
	(0.75)	(0.32)	(0.28)	(0.54)	(0.39)	(0.69)
Rich comm*Round	-6.79***	1.98*	-7.02***	0.90	4.84	-2.98
(interaction)	(0.79)	(1.14)	(1.20)	(0.77)	(3.22)	(5.05)
Constant	1,859.58***	2,482.20***	2,763.15***	2,787.58***	3,174.07***	3,565.36***
	(62.93)	(37.05)	(36.49)	(63.14)	(48.23)	(62.52)
R-squared	0.754	0.245	0.223	0.457	0.025	0.063
Observations	1,140	1,684	2,632	2,500	2,032	924

Note: Standard errors in parentheses based on random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

reduces consumer surplus in all six models shown in the table. For the two parameterizations implemented in the experiment, the surplus reduction is 13 to 36 percent of the surplus in the no communication benchmark (captured in the constant term). The largest relative reduction in surplus occurs in the subgame where neither firm successfully invests in CSR (Models 1 and 4).

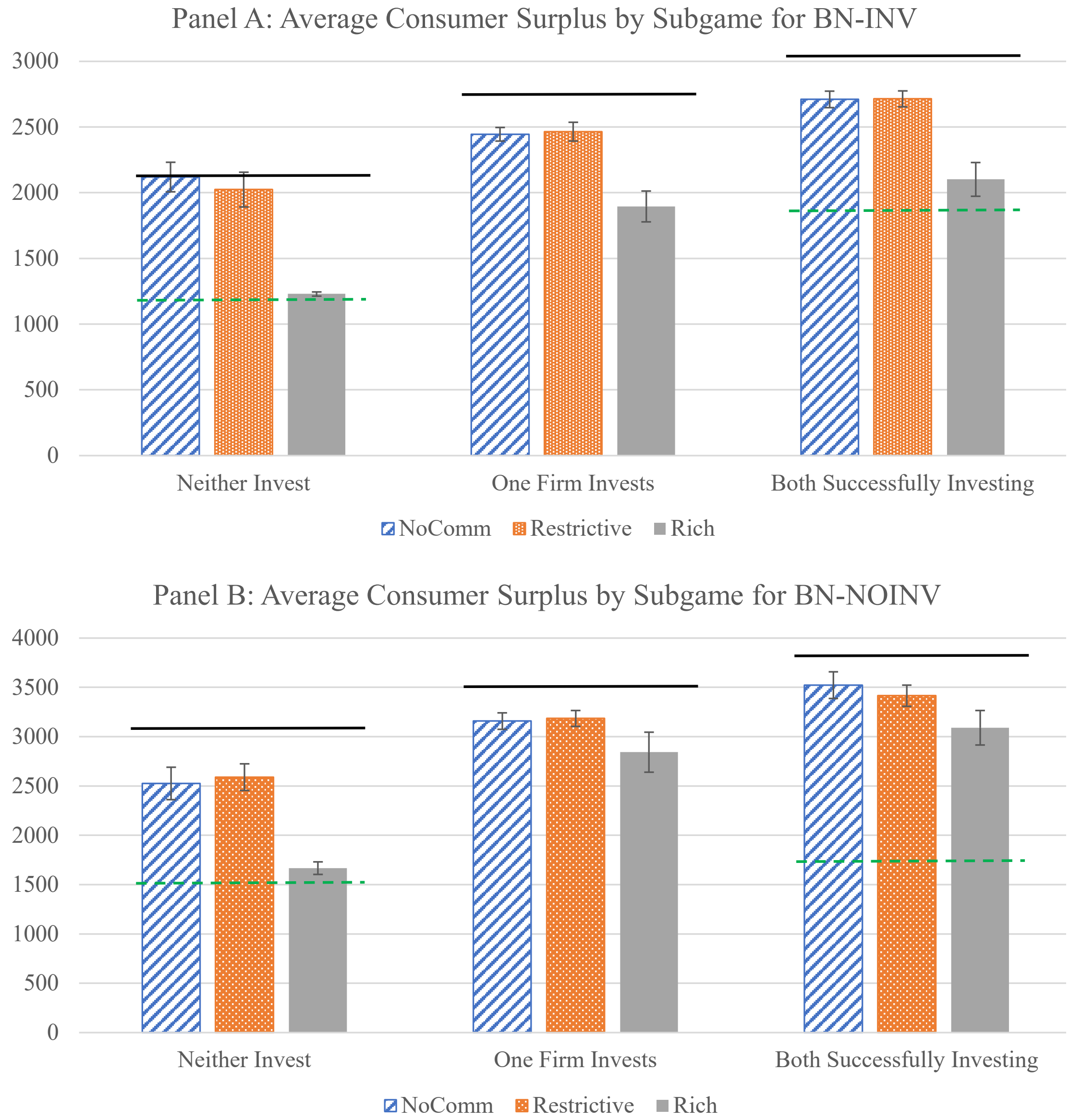
Figure 5 illustrates, however, that average consumer surplus increases as more firms invest in CSR, across all communication treatments. This result follows from the parameter choices of the experiment, as consumers benefit from firms' investment, which also reduces their marginal costs. Only fixed costs increase from investment, which is borne by firms and not consumers.

5 Conclusions

Competition and antitrust authorities are increasingly engaged in widening their regulatory scope beyond the original and fundamental goal of protecting market competition. One expansion in this regulatory responsibility is on utilizing competition policy to shape the functioning of markets in the pursuit of meeting sustainability objectives. More specifically, a key regulation which has gained traction is permitting horizontal cooperation agreements between firms to facilitate coordination on R&D investment, such as CSR. At the same time, the regulatory rules are explicit that such cooperative agreements should not eliminate nor undermine competition, and should avoid potentially adverse welfare implications for consumers. However, it is not clear to what extent allowing for cooperative market arrangements in one domain (i.e., pursuing coordinated CSR investments to the public benefit) affects price formation in the competition stage of the market.

By employing a (two-stage) duopoly Bertrand pricing game, this paper attempts to shed

Figure 5: Average Consumer Surplus for all Treatments and Investment Subgames (all rounds)



Note: Solid black lines denote Bertrand-Nash equilibrium surplus, and dashed green lines denote joint profit maximizing surplus. Error bars designate 95% confidence intervals based on clustered standard errors.

light on the interaction between *cooperative* investment decisions and the *noncooperative* pricing decisions. The dual but sequential investment and price decisions are investigated in a laboratory market experiment that is based on a theoretical model for two distinct strategic environments. One market arrangement constitutes a prisoner's dilemma where both firms investing in CSR is the Nash equilibrium, while both firms not investing is the equilibrium strategy in the other market arrangement. However, in both cases, not investing in CSR is the optimal choice from a joint payoff maximization perspective, while CSR investment increases consumer surplus.

The two market arrangements—reflecting the different nature of the underlying strategic environment—serve as the first treatment variable. The experiment varies as a second treatment variable the communication space that firms have prior to making their CSR investments. Taking a treatment without communication opportunities as a baseline, we explore how firms' investment and price setting compares under restrictive communication limits versus rich communication opportunities. With restrictive communication firms can only send a binary investment or noninvestment signal, whereas under the rich communication setting firms can engage in free bilateral chat. These three communication treatments are a proxy for the competition and antitrust authorities' ability to monitor and scrutinize the firms' cooperative investment agreements and their potential "spillover" effects on the corresponding pricing decisions.

The experimental data reveal that investment rates are significantly lower under rich communication relative to both binary and no communication, and this finding is consistent across both market arrangements. Thus, a lax competition rule, allowing firms to freely coordinate CSR investment decisions, does not seem to be effective in terms of boosting actual investment levels in this strategic environment. Moreover, prices tend to be higher when firms can freely exchange information in the rich communication treatment compared to the case where they have no communication opportunities or can communicate only through binary signaling about investment. Given these higher prices, firm profits with rich communication also significantly exceed profits under no or restrictive communication. Correspondingly, consumer welfare is significantly lower when profits are high, which is particularly noticeable in a rich communication environment.

Our experiment shows that the pursuit of a lax competition/antitrust policy by allowing firms to coordinate and cooperate on CSR investment does not necessarily lead to higher rates of investment; in fact, it may suppress investment and undermine general technological progress in industries. More specifically, in market environments where investment is socially desirable (in our case in the BN-INV scenario), relaxing the rules around CSR cooperation too much could backfire when *not* exempting firms to cooperate on CSR naturally leads to the optimal level of investment. At the same time, allowing firms to freely cooperate on CSR investment may also adversely affect market performance by undermining its ability to generate competitive (and fair) prices and consumer welfare. The importance of securing and protecting consumer surplus should be underscored in assessing collusive sustainability agreements (Veljanovski, 2022)

Although the laboratory market experiment is carefully designed and guided by economic theory, it is implemented based on specific numerical parameters for the two distinct market arrangements. As such, thoughtfulness is required when interpreting the above empirical findings more generally, and more empirical research is needed using field data. However, the experiment's ability to clearly identify the causal impact of investment on pricing decisions provides valuable evidence on how cooperative CSR affects total welfare in imperfectly competitive markets.

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A Theory Appendix

A.1 Proof of Proposition 1

Proof. (5) implies the following results:

$$\pi^b(1,1) - \pi^b(1,0) = \frac{1}{b}\left[q^b(1,1)^2 - q^b(1,0)^2\right] = \left[q^b(1,1) + q^b(1,0)\right]\left[\frac{bc\left\{\widehat{m}(1) - \widehat{m}(0)\right\}}{4b^2 - c^2}\right] < 0, \tag{7}$$

$$\pi^b(0,1) - \pi^b(0,0) = \frac{1}{b}\left[q^b(0,1)^2 - q^b(0,0)^2\right] = \left[q^b(0,1) + q^b(0,0)\right]\left[\frac{bc\left\{\widehat{m}(1) - \widehat{m}(0)\right\}}{4b^2 - c^2}\right] < 0, \tag{8}$$

$$q^b(1,x_j) - q^b(0,x_j) = \frac{-b(2b^2 - c^2)(\widehat{m}(1) - \widehat{m}(0))}{4b^2 - c^2} > 0, \tag{9}$$

where the inequalities hold since $b > c > 0$ and $\widehat{m}(0) > \widehat{m}(1)$. From (7) and (8), $\pi^b(1,1) < \pi^b(1,0)$ and $\pi^b(0,1) < \pi^b(0,0)$, which implies that six orderings of $\pi^b(1,1)$, $\pi^b(1,0)$, $\pi^b(0,1)$ and $\pi^b(0,0)$ are possible: those listed in (a)–(e) of Proposition 1 and $\pi^b(0,1) \leq \pi^b(1,1) \leq \pi^b(1,0) \leq \pi^b(0,0)$. One of the six orderings, $\pi^b(0,1) \leq \pi^b(1,1) \leq \pi^b(1,0) \leq \pi^b(0,0)$— which results in a stag hunt game—is not possible because it contradicts the following inequality implied by (7)–(9):

$$\pi^b(1,1) - \pi^b(1,0) < \pi^b(0,1) - \pi^b(0,0)(< 0).$$[21]

□

A.2 Consumer Surplus

With the utility function (2), consumer surplus v in each round is given by

$$v(p_A, p_B, x_A, x_B) = \frac{1}{2}\beta\left(q_A^2 + q_B^2\right) + \gamma q_A q_B, \tag{10}$$

where $q_i = q(p_i, p_j, x_i, x_j)$ is given by (3) for $i \in \{A, B\}$. When antitrust agencies consider exempting an investment collusion from antitrust regulations, a common requirement is that the collusion does not make the consumers of the relevant good worse off. In view of this practice, we analyze the effect of investment collusion on consumer surplus (10) by comparing the case $(x_A, x_B) = (0,0)$ with the case $(x_A, x_B) = (1,1)$.

Consider a symmetric equilibrium in which the two symmetric firms set a common price in each round of the repeated pricing subgame (from round 1 onwards). Denote this price by p^0 and p^1, where the superscript corresponds to the investment outcome $(x_A, x_B) = (0,0)$ and $(1,1)$. Both p^0 and p^1 fall between the Bertrand-Nash and joint profit maximizing prices, that is, $p^0 \in [p^b(0,0), p^f(0,0)]$ and $p^1 \in [p^b(1,1), p^f(1,1)]$. The equilibrium quantity, profit, and consumer surplus associated with p^0 (p^1) are denoted by q^0 (q^1), π^0 (π^1), and v^0 (v^1), respectively.

Lemma 1. *Whether consumer surplus increases or decreases following investment by both firms depends on whether the price increases more than or less than $w(1)$, the premium the consumer is willing to pay for the quality improvement resulting from the investment:*

$$v^1 \begin{cases} < v^0 & \text{if } p^1 > p^0 + w(1), \\ = v^0 & \text{if } p^1 = p^0 + w(1), \\ > v^0 & \text{if } p^1 < p^0 + w(1). \end{cases} \tag{11}$$

[21] This means that π^b has strictly decreasing differences in (x_1, x_2).

Proof. From (3) and (10),

$$\begin{aligned} v^0 =& (\beta+\gamma)[a-(b-c)p^0]^2, \\ v^1 =& (\beta+\gamma)[a-(b-c)\{p^1-w(1)\}]^2. \end{aligned} \tag{12}$$

Therefore, (11) holds. □

Proposition 2. *Suppose $F(0) \leq F(1)$ and $\widehat{m}(0)-\widehat{m}(1) = m(0)-m(1)+w(1) < 0$. In this case, the firms prefer $(x_A, x_B) = (1,1)$ to $(x_A, x_B) = (0,0)$ only if $p^1 > p^0 + w(1)$, which, according to Lemma 1, implies that investment collusion makes consumers worse off (i.e., $v^1 < v^0$).*

Proof. From (3),

$$\pi^0(p^0) = [p^0 - m(0)][a-(b-c)p^0] - F(0), \tag{13}$$

$$\pi^1(p^1) = [p^1 - m(1)][a-(b-c)\{p^1 - w(1)\}] - F(1), \tag{14}$$

$$\pi^{1\prime}(p^1) = -2(b-c)p^1 + a + (b-c)\{m(1)+w(1)\}. \tag{15}$$

Suppose $p^1 = p^0 + w(1)$. Then $\pi^1(p^0+w(1)) = [p^0 + w(1) - m(1)][a-(b-c)p^0] - F(1)$, so (13) and (14) imply

$$\pi^0(p^0) - \pi^1(p^0+w(1)) = [-m(0) - w(1) + m(1)][a-(b-c)p^0] + F(1) - F(0) > 0, \tag{16}$$

where the last inequality follows from $m(0) - m(1) + w(1) < 0$ and $F(0) \leq F(1)$.

Since $p^0 \leq p^f(0,0) = \frac{1}{2}[m(0) + \frac{a}{b-c}]$,

$$p^0 + w(1) \leq \frac{1}{2}[m(0) + \frac{a}{b-c}] + w(1) < \frac{1}{2}[m(1) + w(1) + \frac{a}{b-c}] \ (= p^f(1,1)). \tag{17}$$

(15), (16), and (17) imply $\pi^0(p^0) > \pi^1(p^0 + w(1))$ and $\pi^{1\prime}(p^0+w(1)) > 0$. Then, since $\pi^{1\prime\prime}(p^1) = -2(b-c) < 0$, a necessary condition for $\pi^0(p^0) \leq \pi^1(p^1)$ is $p^1 > p^0 + w(1)$.

□

An implication of Proposition 2 is that if $\widehat{m}(0) - \widehat{m}(1) < 0$ or, equivalently, if the increase in the marginal production cost due to the investment exceeds the representative consumer's additional willingness to pay for the investment (i.e., $w(1) < m(1) - m(0)$), then exempting investment collusion from antitrust regulation is not justified from the perspective of the antitrust agency whose primary concern is consumer welfare.

With this result in mind, we focus on the opposite case in which $\widehat{m}(0) - \widehat{m}(1) > 0$ and examine whether investment collusion can be justified from the antitrust agency's perspective under this condition.

B Supplementary Results Appendix

Table B-1: Intended Investment Choices, with Lagged Previous Investment and Prices

Linear Probability Model Variable:	Model 1 BN-INV	Model 2 BN-NOINV
Restrictive comm.	-0.014	-0.065***
(dummy)	(0.016)	(0.020)
Rich comm.	-0.079***	-0.216***
(dummy)	(0.029)	(0.041)
Round in session	0.000*	-0.002***
	(0.000)	(0.000)
Rich comm*Round	-0.009***	-0.001
(interaction)	(0.000)	(0.001)
Own Successful	0.052***	0.300***
Investment (lagged)	(0.013)	(0.019)
Other's Successful	0.068***	0.037**
Investment (lagged)	(0.013)	(0.019)
Own Price	-0.029***	-0.042***
(lagged)	(0.007)	(0.010)
Other's Price	-0.002	0.007
(lagged)	(0.006)	(0.009)
More risk averse	0.011	-0.002
(dummy)	(0.015)	(0.018)
Pro-social SVO	0.001	-0.067***
(dummy)	(0.014)	(0.017)
Man	-0.032**	-0.095***
(dummy)	(0.015)	(0.017)
Non-white	-0.012	-0.040**
(dummy)	(0.014)	(0.018)
Upperclassman	-0.040***	0.040**
(dummy)	(0.014)	(0.017)
Constant	0.986***	0.720***
	(0.034)	(0.044)
R-squared	0.592	0.345
Observations	2,604	2,604
Number of subjects	124	124

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

Table B-2: Price Choices in BN-INV Environment by Investment Subgame, with Lagged Previous Investment and Prices

Variable:	Model 1 Neither Invest	Model 2 Only Counterpart	Model 3 Only Self Invest	Model 4 Both Invest
Restrictive comm.	0.325***	-0.137**	0.037	0.010
(dummy)	(0.078)	(0.062)	(0.064)	(0.034)
Rich comm.	1.733***	0.727***	0.710***	0.811***
(dummy)	(0.119)	(0.179)	(0.184)	(0.100)
Round in session	-0.004***	-0.002*	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)
Rich comm*Round	0.006***	-0.009**	-0.001	-0.003
(interaction)	(0.002)	(0.004)	(0.004)	(0.003)
Own Successful	0.162***	-0.027	0.236***	0.156***
Investment (lagged)	(0.050)	(0.066)	(0.071)	(0.038)
Other's Successful	-0.120**	0.054	0.177***	0.093**
Investment (lagged)	(0.049)	(0.067)	(0.068)	(0.038)
Own Price	0.277***	0.352***	0.486***	0.397***
(lagged)	(0.018)	(0.022)	(0.022)	(0.013)
Other's Price	0.161***	0.293***	0.238***	0.328***
(lagged)	(0.018)	(0.021)	(0.023)	(0.012)
More risk averse	-0.204***	-0.058	0.039	-0.041
(dummy)	(0.053)	(0.062)	(0.063)	(0.034)
Pro-social SVO	-0.008	0.102*	0.099	0.147***
(dummy)	(0.051)	(0.060)	(0.062)	(0.034)
Man	0.120**	0.138**	0.200***	0.129***
(dummy)	(0.050)	(0.062)	(0.065)	(0.035)
Non-white	-0.255***	0.022	-0.024	-0.150***
(dummy)	(0.051)	(0.058)	(0.061)	(0.033)
Upperclassman	0.070	0.090	0.017	0.053
(dummy)	(0.048)	(0.059)	(0.063)	(0.033)
Constant	2.724***	1.449***	0.302*	0.493***
	(0.139)	(0.158)	(0.171)	(0.080)
R-squared	0.816	0.480	0.528	0.535
Observations	2,280	1,596	1,596	4,944
Number of subjects	101	116	110	119

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

Table B-3: Price Choices in BN-NOINV Environment by Investment Subgame, with Lagged Previous Investment and Prices

Variable:	Model 1 Neither Invest	Model 2 Only Counterpart	Model 3 Only Self Invest	Model 4 Both Invest
Restrictive comm.	-0.054	-0.021	-0.039	0.090
(dummy)	(0.047)	(0.057)	(0.057)	(0.073)
Rich comm.	0.740***	0.713***	0.071	0.746***
(dummy)	(0.090)	(0.215)	(0.216)	(0.226)
Round in session	0.001	0.001	-0.000	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Rich comm*Round	-0.003*	-0.016*	-0.003	-0.013
(interaction)	(0.001)	(0.009)	(0.009)	(0.012)
Own Successful	-0.057	0.121**	0.177***	0.206***
Investment (lagged)	(0.048)	(0.060)	(0.058)	(0.071)
Other's Successful	0.072	0.181***	0.091	0.192***
Investment (lagged)	(0.046)	(0.056)	(0.057)	(0.069)
Own Price	0.456***	0.283***	0.491***	0.413***
(lagged)	(0.014)	(0.020)	(0.020)	(0.022)
Other's Price	0.298***	0.355***	0.249***	0.283***
(lagged)	(0.013)	(0.019)	(0.020)	(0.022)
More risk averse	-0.116***	-0.082	-0.081	-0.210***
(dummy)	(0.035)	(0.060)	(0.058)	(0.070)
Pro-social SVO	0.048	0.037	0.048	0.100
(dummy)	(0.034)	(0.056)	(0.056)	(0.069)
Man	0.083**	0.002	0.031	-0.025
(dummy)	(0.034)	(0.059)	(0.058)	(0.070)
Non-white	-0.088**	-0.119*	-0.152***	-0.055
(dummy)	(0.035)	(0.063)	(0.057)	(0.074)
Upperclassman	0.027	0.165***	0.037	-0.062
(dummy)	(0.035)	(0.059)	(0.057)	(0.069)
Constant	1.238***	1.146***	0.751***	0.798***
	(0.096)	(0.137)	(0.133)	(0.150)
R-squared	0.740	0.383	0.423	0.419
Observations	4,952	1,924	1,924	1,616
Number of subjects	121	108	96	102

Note: Standard errors in parentheses based on subject random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

Table B-4: Example Chat Communications, BN-INV, Start of Third Supergame Match

Pair Num.	Firm Num.	Message
3	9	Hey, how're you?
3	13	good wbu
3	9	Pretty good, you wanna choose either 7 or 8? Whichever is higher for the both of us
3	9	on the diagonal
3	13	yeah
3	13	this is scary
3	9	Aight, so we both choose either 7 or 8 on the diagonal yea?
3	9	Lmao
3	9	Trust me we'll be aight
3	13	ok
3	9	Win-win scenario for the both of us is best
8	10	hey
8	2	sup
8	10	I say we both don't invest and aim for 7?
8	2	why not invest?
8	10	if we both succeed and do 7 it's 450, if we both don't and do the same thing it's higher
8	2	got it
8	10	oh wait no if we both fail
8	10	lets go with 8
8	2	sure
8	10	ok

Table B-5: Example Chat Communications, BN-NOINV, Start of Third Supergame Match

Pair Num.	Firm Num.	Message
1	5	Hey
1	5	So, its easy
1	1	Both no invest, both $8
1	1	to maximize price
1	5	We both choose do not invest and select 8
1	1	yes
1	5	cool
1	1	at the 4th round dont try to backstab and do 5, because chances are we will get each other again, then if that happens we will compete and drive price down to like $300
1	1	its not worth it.
1	5	Yeah dude, dont worry
1	1	:)
4	2	the way we can make the most money
4	2	is by not investing
4	2	and both picking 8
4	9	bet
4	2	but i have to trust you not to screw me over
4	2	me and my last partner made 777 each time
4	2	so we can make money but you cant screw me
4	9	we have t invest dont we
4	9	to
4	2	dont invest
4	2	we make more that way
4	2	you can choose not to invest
4	2	so dont invest and pick 8
4	9	okay
4	2	if i see you not picking 8 im gonna mess us up

C Instructions Appendix

Introduction

This experiment is a study of group and individual decision making. The amount of money you earn depends partly on the decisions that you make and thus you should read the instructions carefully. The money you earn will be paid privately to you, in cash, at the end of the experiment. A research foundation has provided the funds for this study. Please put away your cell phones and other distracting devices for the duration of the experiment.

This experiment includes 3 parts. You will be given the instructions for the first part and after this is completed, you will be given instructions for the next parts. The instructions describe how the earnings will be determined in each part. These parts are independent, so the decisions and earnings from one part do not affect the decisions and earnings from other parts.

Part 1

Overview

Your earnings in this part will be denoted in experimental Francs. These eFrancs will be converted to U.S. dollars at the rate of 1500 eFrancs = \$1. You will be paid for all rounds in this part, and note that the more eFrancs you earn the more dollars you will leave with at the end of the experiment.

Throughout the experiment you will make decisions privately, without consulting others. Please do not attempt to communicate with other participants in the room during the experiment except when explicitly allowed. If you have a question as you read through the instructions or any time during the experiment, please raise your hand and an experimenter will come by to answer it. At the end of these instructions, you will take a computerized quiz and earn \$1 (in U.S. dollars) for each correct answer.

In Part 1 you will take on the role of a seller who offers products to some computerized buyers. The people in the experiment will be separated into a number of industries. In each of these industries two sellers are active and produce and sell similar products. Each of you represents a seller-producer in a specific industry. The other producer in your industry (who is another person sitting in this room, who we will refer to as your counterpart) is in the same situation with the same conditions as you. You will never learn the identity of your counterpart, which is determined randomly.

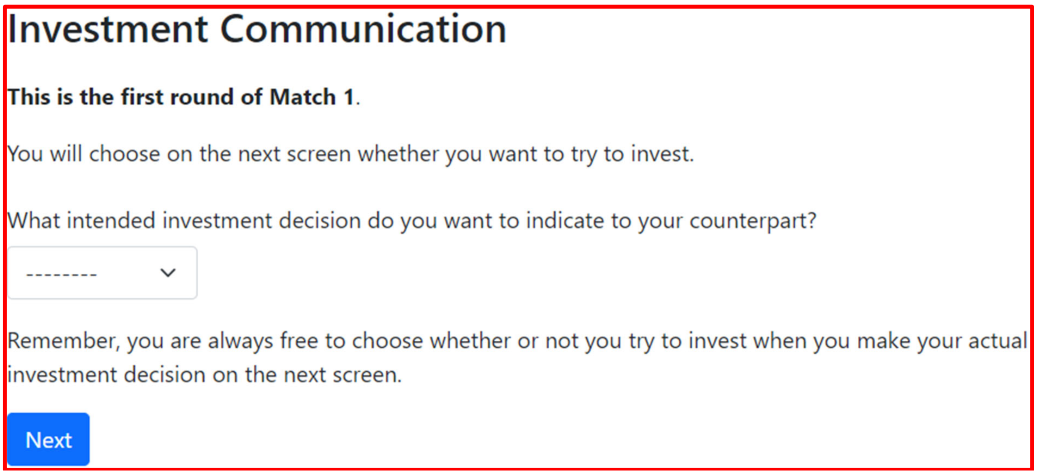
Each producer, including you, has to take an investment decision first and then a sequence of price decisions. The customers who eventually buy your products are simulated by the computer. The rule is: the higher the price of one seller's product compared to the other seller's product, the less products are bought of the higher-priced product and the more of the other product.

What you earn depends on your and your counterpart's investment and price decisions. This will be explained in more detail later. Your investment affects your costs, and it also influences how much the computerized buyers are willing to pay for your product. The combination of costs and buyers' purchase demand determines your earnings. We will summarize this with some "earnings tables" to simplify the calculations. Each time you (and your counterpart) make an investment decision, it will remain constant for 4 consecutive rounds. After all investment decisions are made, you will make price decisions for these 4 rounds. After each of these rounds, you will learn the price chosen by your counterpart and your earnings for that round. You will continue to make price choices (every single round) and new investment decisions (every 4 rounds) for an indeterminant number of rounds, as explained later.

Communication

Note: This paragraph and the following figure are only displayed for Restrictive Communication treatment: Prior to making investment decisions, which as just explained occurs after every

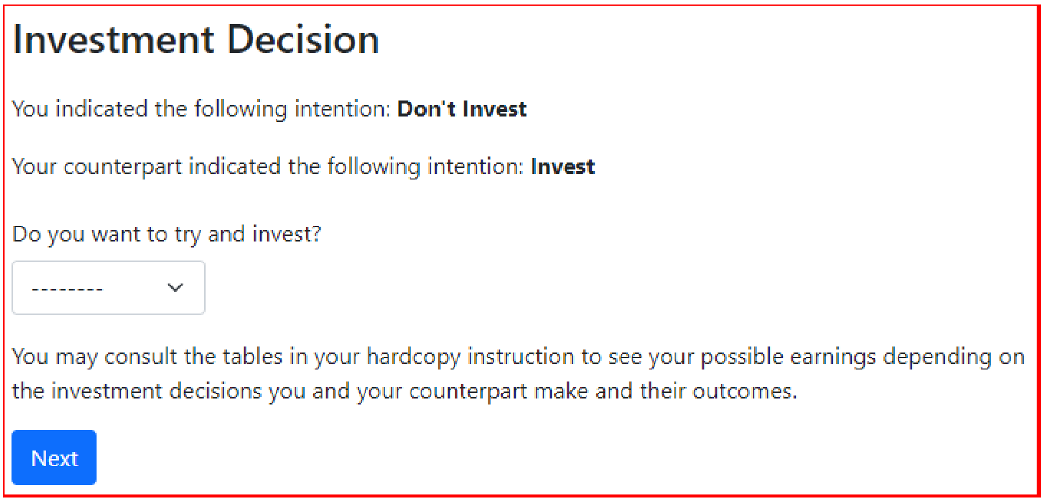
4 rounds, the 2 sellers in each industry will have an opportunity to indicate to their counterpart whether or not they intend to invest for the upcoming rounds. You are always free to choose whether or not you try to invest regardless of what you communicate to your counterpart. This is illustrated in the figure below.



Note: This paragraph is only included for the Rich Communication treatment: Prior to making investment decisions, which as just explained occurs after every 4 rounds, the 2 sellers in each industry will have an opportunity to exchange electronic chat messages for 1 or 2 minutes. The computer will record the messages that are sent. Note, in sending messages back and forth we request that you follow two simple rules: (1) Be civil to each other and use no profanity, and (2) Do not identify yourself by name or number or gender or appearance, or in any other way.

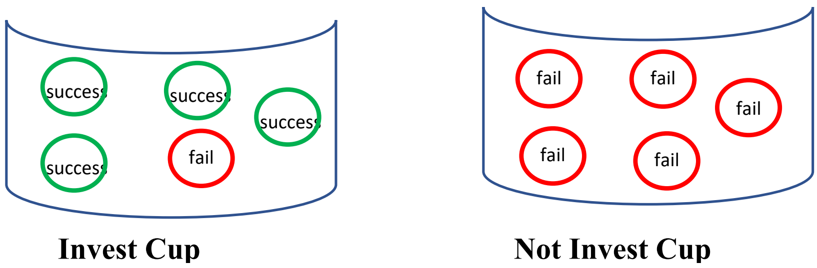
Investment Decision

As illustrated in the figure below, the investment decision is simply a YES or NO decision of whether you wish to take the investment. You make this decision at the same time as your counterpart, and you do not learn your counterpart's decision until after you make yours.



Note: The intentions are only indicated on the Investment Decision screen for the Restrictive Communication treatment.

Whether your investment succeeds and changes your earnings prospects also depends on a random component. If you attempt this investment, success also depends on chance. In particular, your investment succeeds if you choose the investment with only an 80% ("four-fifths") chance. With a one-fifth chance your investment fails and does not change your possible earnings. This is illustrated in the diagram below, where you can visualize a success as occurring if one of the green balls is drawn. Your investment determines whether you draw the ball from an Investment cup (which always has 4 out of 5 balls indicating success) or the No Investment cup (which always has 5 balls indicating failure). Every seller who attempts investment will succeed or not independently from other sellers. This can be visualized by a different ball draw for each seller, and the cups always contain the same 5 balls depending on whether they invested or not.



Price Choices and Earnings Tables

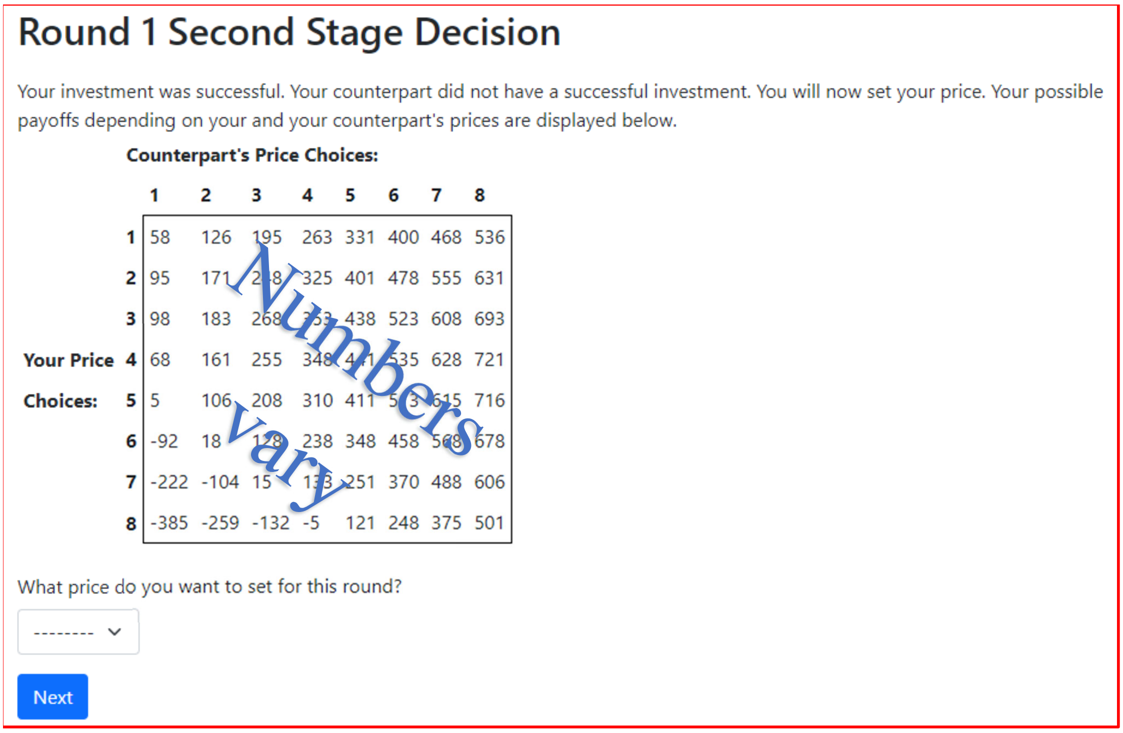
For every combination of investment success (none, one, or both producers choose to invest and are successful), new earnings tables are determined for the following 4 rounds. These are displayed on the last page of these instructions. The entries show your earnings for your price choice (shown in the row selected) and your counterpart's price choice (determined by the column selected).

After the investment decisions are made, as shown below, your price decision screen will display the relevant earnings table that applies for the subsequent 4 rounds. Remember, your counterpart is facing the same situation as you. If only one of you make a successful investment, however, they will be looking at a different earnings table depending on whether they, or you, were the one who succeeded.

New Counterparts in New Matches

As explained earlier, you will be randomly grouped with a counterpart to be the only 2 sellers in an industry. You will continue to be grouped with this same counterpart for some rounds, which we call a "match." During each match you will make price choices (every round) and investment decisions (once every 4 rounds). The length of a match, that is, the number of rounds in a match, is randomly determined as follows:

After each round, there is a 7/8 (87.5%) probability that the match will continue for at least another round. Specifically, after each round, whether the match continues for another round will be determined by a random number between 1 and 100 generated by the computer. (All numbers in this range are equally likely.) If the number is lower than or equal to 87.5 the match will continue for at least another round, otherwise it will end. For example, if you are in round 2, the probability that there will be a third round is 7/8 and if you are in round 9, the probability that there will be a tenth round is also 7/8. At any point in a match, the probability that the match will continue is 7/8.



Round 1 Second Stage Decision

Your investment was successful. Your counterpart did not have a successful investment. You will now set your price. Your possible payoffs depending on your and your counterpart's prices are displayed below.

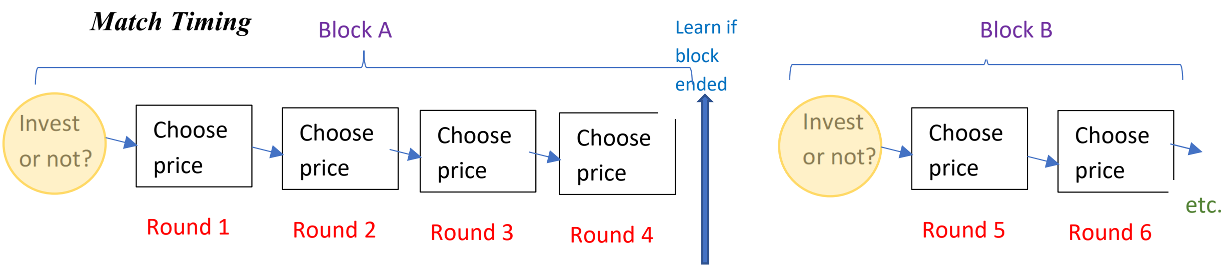
Counterpart's Price Choices:

		1	2	3	4	5	6	7	8
	1	58	126	195	263	331	400	468	536
	2	95	171	[illegible]	325	401	478	555	631
	3	98	183	268	[illegible]	438	523	608	693
Your Price	**4**	68	161	255	348	[illegible]	535	628	721
Choices:	**5**	5	106	208	310	411	[illegible]	615	716
	6	-92	18	128	238	348	458	568	678
	7	-222	-104	15	133	251	370	488	606
	8	-385	-259	-132	-5	121	248	375	501

Numbers vary

What price do you want to set for this round?

Next



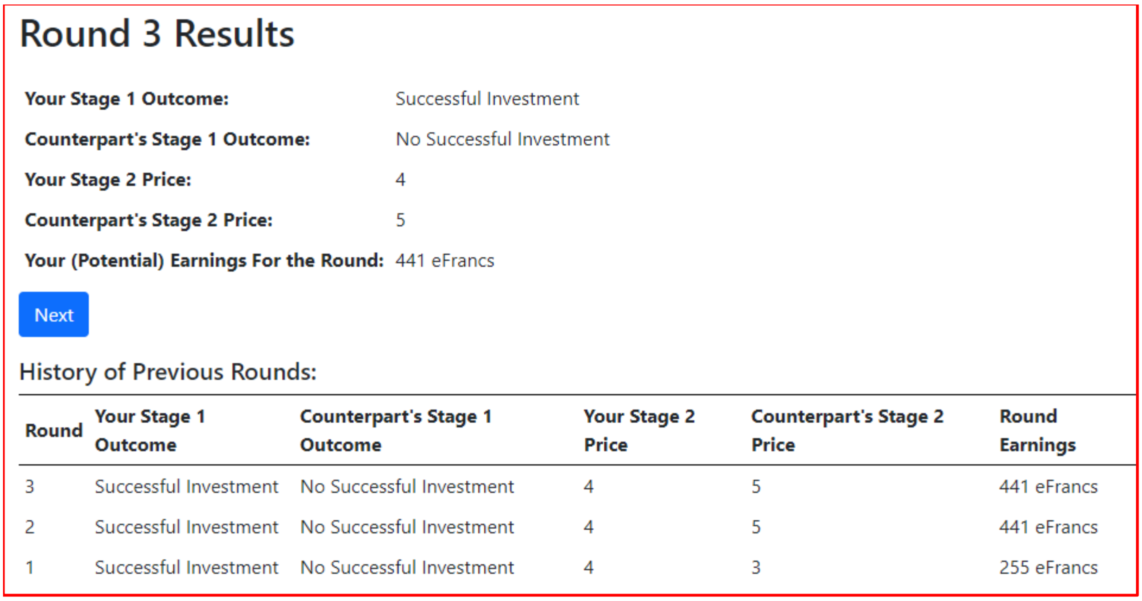
Note: Number of Rounds in a Match is determined randomly

However, you will play every match in blocks of 4 rounds. At the end of each block, you will learn if the match ended in the previous block of 4 rounds or not. If it has not, you will play another block of 4 rounds. If the match has ended in this block, you will see in which round it had actually ended. In particular, you will be informed of the random numbers generated by the computer for each round at the end of every 4 rounds. The final round of the match will be the first round where the random number generated by the computer was greater than 87.5. Total earnings for each match are the sum of earnings received for each round of that match. You will NOT receive any earnings from rounds you've played within a block after the match had ended.

Once a match ends, you will be randomly grouped with someone for a new match. You will not be able to identify who you've interacted with in previous or future matches. This part of the experiment will end after 10 matches have been completed.

Summary

- In this part you will make choices as a seller-producer for a series of 10 matches.



Round 3 Results

Your Stage 1 Outcome:	Successful Investment
Counterpart's Stage 1 Outcome:	No Successful Investment
Your Stage 2 Price:	4
Counterpart's Stage 2 Price:	5
Your (Potential) Earnings For the Round:	441 eFrancs

Next

History of Previous Rounds:

Round	Your Stage 1 Outcome	Counterpart's Stage 1 Outcome	Your Stage 2 Price	Counterpart's Stage 2 Price	Round Earnings
3	Successful Investment	No Successful Investment	4	5	441 eFrancs
2	Successful Investment	No Successful Investment	4	5	441 eFrancs
1	Successful Investment	No Successful Investment	4	3	255 eFrancs

- Each match will consist of a randomly-determined number of rounds, in which you are grouped with the same counterpart repeatedly.
- In each round you and your counterpart will make a price decision, which determines your earnings.
- Once every 4 rounds the 2 sellers in each industry will have an opportunity to indicate to their counterpart whether or not they intend to invest for the upcoming rounds. They will then make a YES or NO investment decision that applies for the next 4 rounds.
- Investment succeeds in affecting your earning prospects with an 80
- The combination of investment decisions and successes determines which earnings table applies for these following 4 rounds.
- You will be paid for every round of this part, except that you will NOT receive any earnings from rounds you've played within a 4-round block after the match had ended.

Experiment Instructions – Part 2 *Displayed on oTREE computer screens*

This is an individual task. You will be shown five options and will be asked to choose the one you prefer. Each option has two possible outcomes, both with equal (50%) chance of occurring. Your earnings from this part will depend on which option you choose, and which outcome occurs.

The options are as follows:

Table C-1: Part 2 Options and Outcomes

Option	Random numbers 1-50 (50% chance)	Random numbers 51-100 (50% chance)
1	You earn $2	You earn $2
2	You earn $3	You earn $1.50
3	You earn $4	You earn $1
4	You earn $5	You earn $0.50
5	You earn $6	You earn $0

After you have chosen one of these options, the computer will randomly draw a whole number between 1 and 100 (inclusive). If the random number is 50 or less, your earnings from this part are as shown in the middle column of the table. If the random number is 51 or more, your earnings from this part are as shown in the right column of the table. The random number drawn for you may be different from the ones drawn for other participants.

Once everyone has chosen an option, you will proceed to the next part.

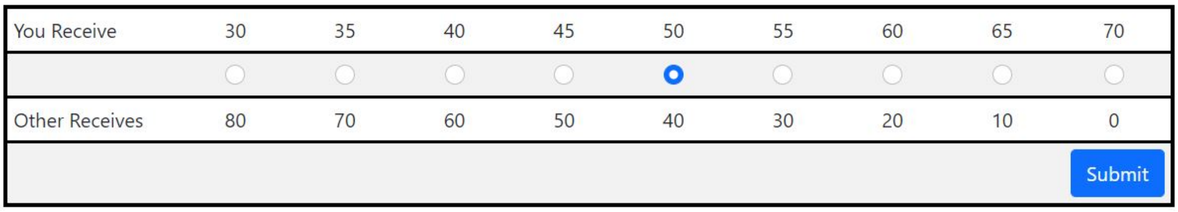
At the end of the experiment, you will be informed of the results of this part: your choice of option, your random number, and your earnings.

Experiment Instructions – Part 3 *Displayed on oTREE computer screens*

In this part of the study, you will be randomly paired with another person, whom we will refer to as the **other**. You will not know who the other person is, nor will the other person be informed about your identity. You will make a series of choices among several alternative allocations of Points. These Points will be converted into Dollars at a rate of **1 Point = 0.05 Dollars.**

You will be making a series of decisions about allocating points between you and this other person. For each of the questions, please indicate the distribution you prefer most by selecting the corresponding button in the middle row. You can only make one choice for each question. There are no right or wrong answers, this is all about personal preference.

Diagram: Example of an allocation choice. In the example below, a person chose the allocation giving 50 Points to herself, and 40 Points to the unknown other person. In terms of Dollars, this yields an allocation of 50x0.05=$2.50 Dollars for the person making the choice and 40x0.05=2 Dollars for the unknown other.



As you can see, your choices influence both the number of Points you receive, as well as the number of Points the other person receives.

After you have made all your choices, one of the allocation choices will be randomly selected by the software. For this choice, the software will randomly assign one person from your group (you or the other) the role of “Receiver” and the other the role of the “Sender”. The allocation choice made by the Sender will be enforced. This allocation will be paid in cash to both the Sender and the Receiver.

If you have any questions, please raise your hand.

Note: Final pages of the hardcopy instructions included these two pages

How to Read the Earnings Tables

You always make choices from the point of view of the Row person, with your price determining which row is used to indicate your earnings. This is indicated in green on the tables. Your counterpart also chooses a price, which determines which column is used (shown in red).

Your earnings in eFrancs are shown here

Neither seller succeeds

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	[illegible]
	1	92	133	175	217	258	300	342	383
	2	150	200	250	300	350	400	450	500
Own	3	175	233	292	350	408	467	525	583
Price	4	167	233	300	367	433	500	567	633
Choice	5	125	200	275	350	425	500	575	650
	6	50	133	217	300	383	467	550	633
	7	-58	33	125	217	308	400	492	583
	8	-200	-100	0	100	200	300	400	500

Because you can choose from 8 different prices, and so can your counterpart, you could earn 64 different amounts depending on the different price choice combinations.

Consider the following example, which is based on the earnings table when both you and your counterpart have invested and were successful. In this example we have randomly chosen a price of 3 for you and 4 for your counterpart. These prices are highlighted in yellow. The intersection indicates your earnings for this round, 442. Since your counterpart chose a price of 4 and you chose a price of 3, from your counterpart's point of view this results in earnings of 300 for them.

Both sellers succeed

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	8
	1	200	275	350	425	500	575	650	725
	2	200	283	367	450	533	617	700	783
Own	3	167	258	350	442	533	625	717	808
Price	4	100	200	300	400	500	600	700	800
Choice	5	0	108	217	325	433	542	650	758
	6	-133	-17	100	217	333	450	567	683
	7	-300	-175	-50	75	200	325	450	575
	8	-500	-367	-233	-100	33	167	300	433

All Earnings Tables for Different Combinations of Investment Success

Neither seller succeeds

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	8
	1	92	133	175	217	258	300	342	383
	2	150	200	250	300	350	400	450	500
Own	3	175	233	292	350	408	467	525	583
Price	4	167	233	300	367	433	500	567	633
Choice	5	125	200	275	350	425	500	575	650
	6	50	133	217	300	383	467	550	633
	7	-58	33	125	217	308	400	492	583
	8	-200	-100	0	100	200	300	400	500

Row seller succeeds

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	8
	1	275	350	425	500	575	650	725	800
	2	283	367	450	533	617	700	783	867
Own	3	258	350	442	533	625	717	808	900
Price	4	200	300	400	500	600	700	800	900
Choice	5	108	217	325	433	542	650	758	867
	6	-17	100	217	333	450	567	683	800
	7	-175	-50	75	200	325	450	575	700
	8	-367	-233	-100	33	167	300	433	567

Column seller succeeds

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	8
	1	50	92	133	175	217	258	300	342
	2	100	150	200	250	300	350	400	450
Own	3	117	175	233	292	350	408	467	525
Price	4	100	167	233	300	367	433	500	567
Choice	5	50	125	200	275	350	425	500	575
	6	-33	50	133	217	300	383	467	550
	7	-150	-58	33	125	217	308	400	492
	8	-300	-200	-100	0	100	200	300	400

Both sellers succeed

		Counterpart's Price Choices							
		1	2	3	4	5	6	7	8
	1	200	275	350	425	500	575	650	725
	2	200	283	367	450	533	617	700	783
Own	3	167	258	350	442	533	625	717	808
Price	4	100	200	300	400	500	600	700	800
Choice	5	0	108	217	325	433	542	650	758
	6	-133	-17	100	217	333	450	567	683
	7	-300	-175	-50	75	200	325	450	575
	8	-500	-367	-233	-100	33	167	300	433