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 presents a theoretical model and experiment to investigate how potential cooperation between firms on corporate social responsibility (CSR) investments affects subsequent price competition. In an initial stage, duopolists make a binary sustainability investment decision (e.g., corresponding to waste and pollution reduction, energy efficient technology adoption, etc.) that affects their costs. Investment also shifts demand, as some consumers value sustainability. In later stages firms set prices simultaneously in a sequence of indefinitely repeated rounds. To investigate how cooperation in CSR investments affect price competition, in some treatments the sellers can communicate in the investment stage. The experiment implements communication using free-form chat or more restrictive messages focused on the investment decision in different treatments. 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 experimental results reveal that investment rates are significantly lower with rich communication than 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.

Keywords: Collusion; Duopoly; Antitrust; Competition policy; Communication; Experiment

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1 Introduction

Keeping markets competitive has predominantly been the primary objective of competition policy and antitrust regulation. However, competition and antitrust authorities are gradually altering this core mission and utilise their regulatory toolkit to facilitate industry arrangements that meet broader societal-wide objectives (Shapiro, 2021). Sustainability is a case in point, 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 (or removing) of plastics in consumer products, among others.

One concrete proposal that has been implemented is to allow firms at the same level of the supply chain to cooperate on R&D agreements on the condition that it generates wider (public) benefits, such as in the aforementioned sustainability examples. Although competition law originally 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 being pursued by the competition and market authorities in the Netherlands and the UK, for example. A recent theoretical literature has emerged that investigates the interaction between horizontal agreements and the impact on sustainable production and consumption (Schinkel and Spiegel, 2017; Treuren and Schinkel, 2018; 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).

A natural issue that arises concerns the possibility that cooperative R&D arrangements may adversely impact competition in the output market (Cooper and Ross, 2009) and could result in tacit collusion in the product market (Martin, 1996; Cabral, 2000). In the context of horizontal cooperative agreements targeted towards sustainable investments, a fundamental and important question is then whether these agreements can facilitate tacit price collusion between firms. The potential threat of collusive pricing can distort overall market performance despite mission-driven sustainability objectives. This question is, of course, difficult to answer with only theory. Here we design and implement a market experiment that allows us to give an answer to this question, and we contribute to the literature by providing some 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 literature does not explore the "spillover" potential of cooperative investment on price formation, we build on a surprisingly sparse experimental literature. Perhaps the closest to ours is the study by 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 the 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 communication rules have 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.

In a laboratory experiment, Cason and Gangadharan (2013) study the interaction between R&D cooperation and competition and find that the propensity to cooperate is lower in competitive market environments. More importantly for the question we are interested in, their results show no significant spillover effect from cooperation on competition in terms of collusive pricing behavior. This result is robust even when communication opportunities between producers is introduced, i.e., allowing communication in their experimental market environments does not give rise to collusive practices amongst players.

More recently, Casoria and Ciccone (2021) experimentally investigate whether upfront investment opportunities are conducive to cooperation for players in an infinitely repeated prisoner's dilemma game. In this strategic environment, the payoff from cooperation is higher post investment. 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 environmental sustainability goals.

Our experiment builds on Casoria and Ciccone (2021) by explicitly acknowledging the link between investment and cooperation. In our model we consider cooperation on actual investment decisions, and then assess 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 through the lens of potential collusive pricing behavior. The identification strategy to explore this is by exploiting the opportunity to communicate as an investment coordination channel between players. Allowing for communication opportunities is another key difference between our experiment and Casoria and Ciccone (2021).

Our experiment exploits 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 the experiment by Cason (2000) where communication is akin to lax antitrust enforcement, while prohibiting communication reflects active antitrust enforcement. In our experiment, prohibiting communication is used as 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. These three communication rules represent the regulatory authority's ability to monitor and inspect the firms' cooperation on investment agreements and its 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.

2 Model

2.1 Demand and Cost Structure

As a theoretical model to assess the effects of firms' CSR investments on product prices and consumer/social welfare, we consider a duopolistic market where two symmetric firms (denoted by $i \in \{A, B\}$) play a repeated game as described below. In the initial round (round 0), each firm makes a binary investment decision $x_i \in \{0, 1\}$, with $x_i = 1$ indicating investment in CSR and $x_i = 0$ no investment in CSR, respectively.[1] The firm incurs the fixed cost of $F(x_i)$ depending on its investment choice, where $F(0) < F(1)$.

Given the initial-round investment decisions (x_A, x_B), the two firms repeatedly interact by simultaneously setting prices in each of 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 a continuation probability δ. In each pricing round, the firms set prices under the following demand and cost structures. Denoting product i's price by p_i and quantity by q_i, we consider a linear inverse demand function given by

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

where $\alpha > 0$, $\beta > \gamma > 0$, and $w(1)$ is the representative consumer's willingness to pay (WTP) for firm i's CSR investment in the sense that it reflects the premium she is willing to pay for product i's quality improvement due to firm i's CSR investment, relative to the case of no such investment (i.e., $w(0) = 0$).[2,3] Inverting this system of inverse demand functions gives the corresponding demand functions for both goods:

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

[1]CSR investments can be interpreted broadly and can relate to investment in product quality, investment in production processes, or sustainability targeted R&D more generally.

[2]This demand system results from the representative consumer's utility maximization under the following utility function which is quasi-linear in the amount of the composite, numéraire good (z):

$$U(z, q_A, q_B; x_A, x_B) = z - 0.5\left[\beta(q_A^2 + q_B^2) + 2\gamma q_A q_B\right] + \sum_{i \in \{A,B\}} \left[\alpha + w(x_i)\right] q_i. \tag{2}$$

[3]Note that $w(1)$ is the value of CSR perceived by the consumer, which may be different from its value from a social perspective.

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 due to firm i's CSR investment.

Firm i's marginal cost of production (in the second and subsequent stages) conditional on x_i is denoted by $m(x_i)$. For later use, we define the quality-adjusted marginal cost $\widehat{m}(x_i)$:

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

Because $w(0) = 0$, $\widehat{m}(0) = m(0)$. If $m(0) > \widehat{m}(1)$ or, equivalently, $m(0) - m(1) + w(1) > 0$, then the net marginal *private* benefit of firm i's CSR investment to the firm and the representative consumer together is positive.

2.2 Bertrand-Nash and Fully Collusive Pricing

Under the framework described above, two benchmark equilibrium paths possible in the repeated pricing subgame are Bertrand-Nash pricing in every round and fully collusive (joint profit maximizing) pricing in every round. In principle, these Bertrand-Nash and fully collusive cases can be considered the lower and upper bounds between which actual outcomes are likely to fall.

2.2.1 Bertrand-Nash Pricing

Consider the case in which the Bertrand-Nash equilibrium is realized in each pricing round, conditional on investment choices (x_1, x_2) in the initial round. In principle, this benchmark case constitutes a lower bound of the equilibrium prices and payoffs realized in the repeated pricing subgame conditional on (x_1, x_2). The Bertrand-Nash equilibrium price $p^b(x_i, x_j)$ and quantity $q^b(x_i, x_j)$ of product i in each round, and the discounted sum of firm i's payoff $\Pi^b(x_i, x_j)$ over the pricing rounds are as follows:

$$\begin{aligned}
p^b(x_i, x_j) &= \frac{2b\left[a + b\widehat{m}(x_i)\right] + c\left[a + b\widehat{m}(x_j)\right]}{4b^2 - c^2} + w(x_i) \\
q^b(x_i, x_j) &= \frac{b\left[2ba + ca - (2b^2 - c^2)\widehat{m}(x_i) + bc\widehat{m}(x_j)\right]}{4b^2 - c^2} \\
\Pi^b(x_i, x_j) &= \frac{q^b(x_i, x_j)^2}{(1-\delta)b} - F(x_i)
\end{aligned} \tag{5}$$

Proposition 1. *Given $F(0) < F(1)$ and $m(0) - m(1) + w(1) > 0$, only the following five orderings of $\Pi^b(0,0)$, $\Pi^b(1,0)$, $\Pi^b(0,1)$, and $\Pi^b(1,1)$ are possible:*[4]

(a) $\Pi^b(0,1) \leq \Pi^b(0,0) \leq \Pi^b(1,1) \leq \Pi^b(1,0)$

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

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

(d) $\Pi^b(1,1) \leq \Pi^b(1,0) \leq \Pi^b(0,1) \leq \Pi^b(0,0)$

(e) $\Pi^b(1,1) \leq \Pi^b(0,1) \leq \Pi^b(0,0) \leq \Pi^b(1,0)$

[4] The assumption of symmetric demand and cost functions is unnecessary for this result.

The reasoning for the assumption $m(0) - m(1) + w(1) > 0$ is considered in Section 2.3 below. Proposition 1 suggests that if the Bertrand-Nash equilibrium (5) occurs in each subsequent pricing round, the reduced game at the initial round will conform to one of the five cases in Table 1.

Table 1: Reduced Game with Bertrand-Nash Pricing

(a)

		Firm j: $x_j = 0$	Firm j: $x_j = 1$
Firm i	$x_i = 0$	(Π_2, Π_2)	(Π_1, Π_4)
	$x_i = 1$	(Π_4, Π_1)	(Π_3, Π_3)

(b)

		Firm j: $x_j = 0$	Firm j: $x_j = 1$
Firm i	$x_i = 0$	(Π_3, Π_3)	(Π_1, Π_4)
	$x_i = 1$	(Π_4, Π_1)	(Π_2, Π_2)

(c)

		Firm j: $x_j = 0$	Firm j: $x_j = 1$
Firm i	$x_i = 0$	(Π_4, Π_4)	(Π_2, Π_3)
	$x_i = 1$	(Π_3, Π_2)	(Π_1, Π_1)

(d)

		Firm j: $x_j = 0$	Firm j: $x_j = 1$
Firm i	$x_i = 0$	(Π_4, Π_4)	(Π_3, Π_2)
	$x_i = 1$	(Π_2, Π_3)	(Π_1, Π_1)

(e)

		Firm j: $x_j = 0$	Firm j: $x_j = 1$
Firm i	$x_i = 0$	(Π_3, Π_3)	(Π_2, Π_4)
	$x_i = 1$	(Π_4, Π_2)	(Π_1, Π_1)

Note: $\Pi_1 \leq \Pi_2 \leq \Pi_3 \leq \Pi_4$.

In Cases (a) and (b) of Table 1, investing is the dominant strategy for both firms, resulting in equilibrium investment choices of $(1, 1)$. 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 equilibrium investment choices of $(0, 0)$. Case (e) is a chicken game, with only one firm investing in the corresponding equilibrium. Given demand and marginal cost parameters, as $F(1) - F(0)$ increases, the type of the reduced game changes in this order: Table 1 (a) $\rightarrow$ (b) $\rightarrow$ (e) $\rightarrow$ (c) $\rightarrow$ (d). Because the range of $F(1) - F(0)$ within which a chicken game results is limited, our experiment will focus on a case in which investing is the dominant strategy (case (b), which we call BN-INV in the next section) and another case in which not investing is the dominant strategy (case (c), which we call BN-NOINV in the next section).

2.2.2 Fully Collusive Pricing

Consider other 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 $(1, 1)$. Table 2 summarizes fully collusive price p^f and quantity q^f in each round, and the payoff Π^{fc} over the rounds. For comparison, Table 2 also lists the Bertrand-Nash outcomes conditional on $(x_A, x_B) = (0, 0)$ or $(1, 1)$. As a matter of course, we have $p^b(x, x) < p^f(x, x)$, $q^b(x, x) > q^f(x, x)$, and $\Pi^b(x, x) < \Pi^f(x, x)$ for both $x = 0$ and 1.

Table 2: Prices, Quantities and Profits

Bertrand-Nash	Full Collusion
$p^b(x,x) = \frac{a+b\widehat{m}(x)}{2b-c} + w(x)$	$p^f(x,x) = \frac{a}{2(b-c)} + \frac{\widehat{m}(x)}{2} + w(x)$
$q^b(x,x) = \frac{b[a-(b-c)\widehat{m}(x)]}{2b-c}$	$q^f(x,x) = \frac{a-(b-c)\widehat{m}(x)}{2}$
$\Pi^b(x,x) = \frac{q^b(x,x)^2}{(1-\delta)b} - F(x)$	$\Pi^f(x,x) = \frac{q^f(x,x)^2}{(1-\delta)(b-c)} - F(x)$

Actual equilibrium outcomes are likely to fall between these two polar cases.

2.3 Consumer Surplus

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

$$v(p_A, p_B, x_A, x_B) = 0.5\beta(q_A^2 + q_B^2) + \gamma q_A q_B, \tag{6}$$

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 reduce the welfare of the consumers of the relevant good. In view of this practice, we analyze the effect of investment collusion on consumer surplus (6) by comparing the case of no firm investing, $(x_A, x_B) = (0, 0)$, with the case of both firms investing, $(x_A, x_B) = (1, 1)$.

Suppose that in an equilibrium path of the repeated pricing subgame (from round 1 onwards) conditional on investment choices, both firms set a common price (denoted by p^0 or p^1 for the respective investment outcome $(x_A, x_B) = (0, 0)$ or $(1, 1)$) in each pricing round, where p^0 and p^1 fall between the respective Bertrand-Nash price and joint profit maximizing price (i.e., $p^0 \in [p^b(0, 0), p^f(0, 0)]$ and $p^1 \in [p^b(1, 1), p^f(1, 1)]$). Each firm's quantity (in each round) associated with p^0 or p^1 is given by (3) and detneod by q^0 or q^1, respectively. Similarly, each firm's payoff (over the rounds) corresponding to p^0 or p^1 is denoted by Π^0 or Π^1, respectively.

Consumer surplus resulting from $(x_A, x_B) = (0, 0)$ and p^0 is denoted by V_0 and equals

$$V^0 = \frac{v(p^0, p^0, 0, 0)}{1-\delta} = \frac{(\beta+\gamma)(q^0)^2}{1-\delta}. \tag{7}$$

Likewise, consumer surplus resulting from $(x_A, x_B) = (1, 1)$ and p^1 is denoted by V^1:

$$V^1 = \frac{v(p^1, p^1, 1, 1)}{1-\delta} = \frac{(\beta+\gamma)(q^1)^2}{1-\delta}. \tag{8}$$

Lemma 1. *Whether consumer surplus increases or decreases after investment by both firms depends on whether the price increases more than or less than $w(1)$, or the representative consumer's additional willingness to pay for the investment:*

$$V^1 \begin{cases} < V^0 & \text{if } p^1 > p^0 + w(1), \\ = V^0 & \text{if } p^1 = p^0 + w(1), \\ > V^0 & \text{if } p^1 < p^0 + w(1). \end{cases} \tag{9}$$

Proposition 2. *Suppose $F(0) < F(1)$ and that the net marginal private benefit of investment is negative (i.e., $m(0) - m(1) + w(1) < 0$). In this case, the firms prefer $(x_A, x_B) = (1, 1)$ to $(x_A, x_B) = (0, 0)$ only if $p^1 > p^0 + w(1)$, meaning that investment collusion makes consumers worse off (i.e., $V^1 < V^0$).*

An implication of Proposition 2 is that if the net marginal private benefit of investment is negative or, equivalently, if the increase in the marginal production cost due to the investment outweighs the representative consumer's additional willingness to pay for the investment (i.e., $w(1) < m(1) - m(0)$), exempting an investment collusion from antitrust regulations is not justified from the viewpoint of the antitrust agency whose top priority is consumer welfare.

With this result in mind, hereafter we focus on the opposite case in which the net marginal private benefit of investment is positive (i.e., $m(0) - m(1) + w(1) > 0$) and analyze whether or not investment collusion can be justified from the antitrust agency's perspective in this case.

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 treatments 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. By contrast, in the BN-NOINV treatment *not* investing in CSR is the perfect Nash equilibrium with Bertrand-Nash pricing.

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

Table 3: Numerical Parameter Values for Two Strategic Environments

Parameter	Meaning	BN-INV	BN-NOINV
β	Own-quantity inverse demand coefficient	2	2
γ	Own-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 (Joint Payoff Max)	8	8
	Both invest (Joint Payoff Max)	6	8

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

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, 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 CSR investments made for that round.[5] The instructions Appendix A 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. Thie (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.[6]

[5]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.

[6]The experiment employed different exchange rates from experimental currency to U.S. dollars for the two treatments due to the greater equilibrium and collusive earnings in BN-NOINV. The exchange rate was 1500 to \$1 for BN-INV and 2400 to \$1 for BN-NOINV.

Table 4: Equilibrium Earnings for Each Subgame

BN-INV

	Not Invest	Invest
Not Invest	367, 367	175, 450
Invest	450, 175	283, 283

BN-NOINV

	Not Invest	Invest
Not Invest	441, 441	230, 426
Invest	426, 230	159, 159

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

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. 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 $(1-7/8)^{-1} = 8$. Following a standard practice, 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 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.[7]

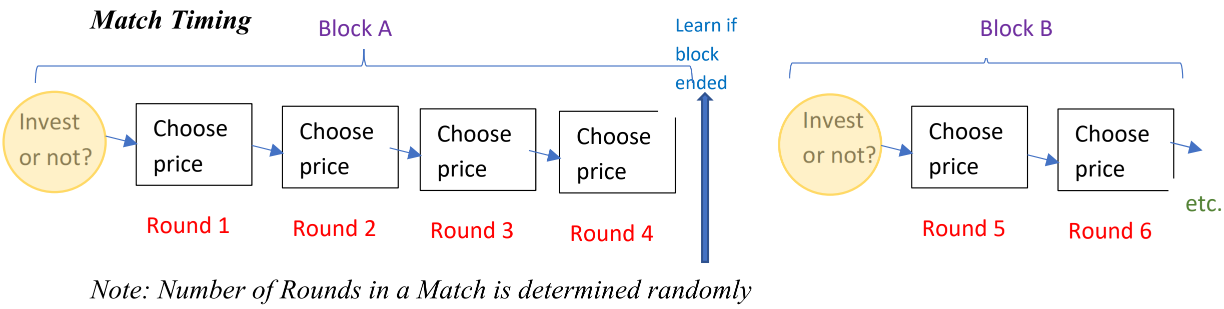
To capture the fact that price choices are usually more frequent than investment choices, firms made their investment choices once every four pricing rounds. Figure 1 illustrates how this was displayed in the instructions and explained to subjects. It also indicates that the experiment employed block 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.[8]

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 abandonded 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, but did not learn whether they tried to invest or not. Due to this

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

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

Figure 1: Timeline within each Supergame Match



randomness introduced in the investment realization, it was not uncommon that only one firm realized investment success even when both firms attempted to invest.

3.3 Communication Treatments

Finally, the experiment sought to measure the impact of different communication opportunities between firms on their investment and pricing decisions:

- **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 next four 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.[9] 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 potentail agreements between firms to collaborate on CSR investments. The binary message in the restrictive communication treatment is a

[9]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."

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.

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 shofted 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.

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.[10] In the second stage of each round, following realization 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 A).

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 A). 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 of [$23.75, $30.25].

[10] 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."

4 Results

We present the results in five subsections. Subsection 4.1 compares firms' intended 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 investment choices in the restrictive communication treatment. The final Subsection 4.5 reports consumer surplus and total welfare. 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.

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).

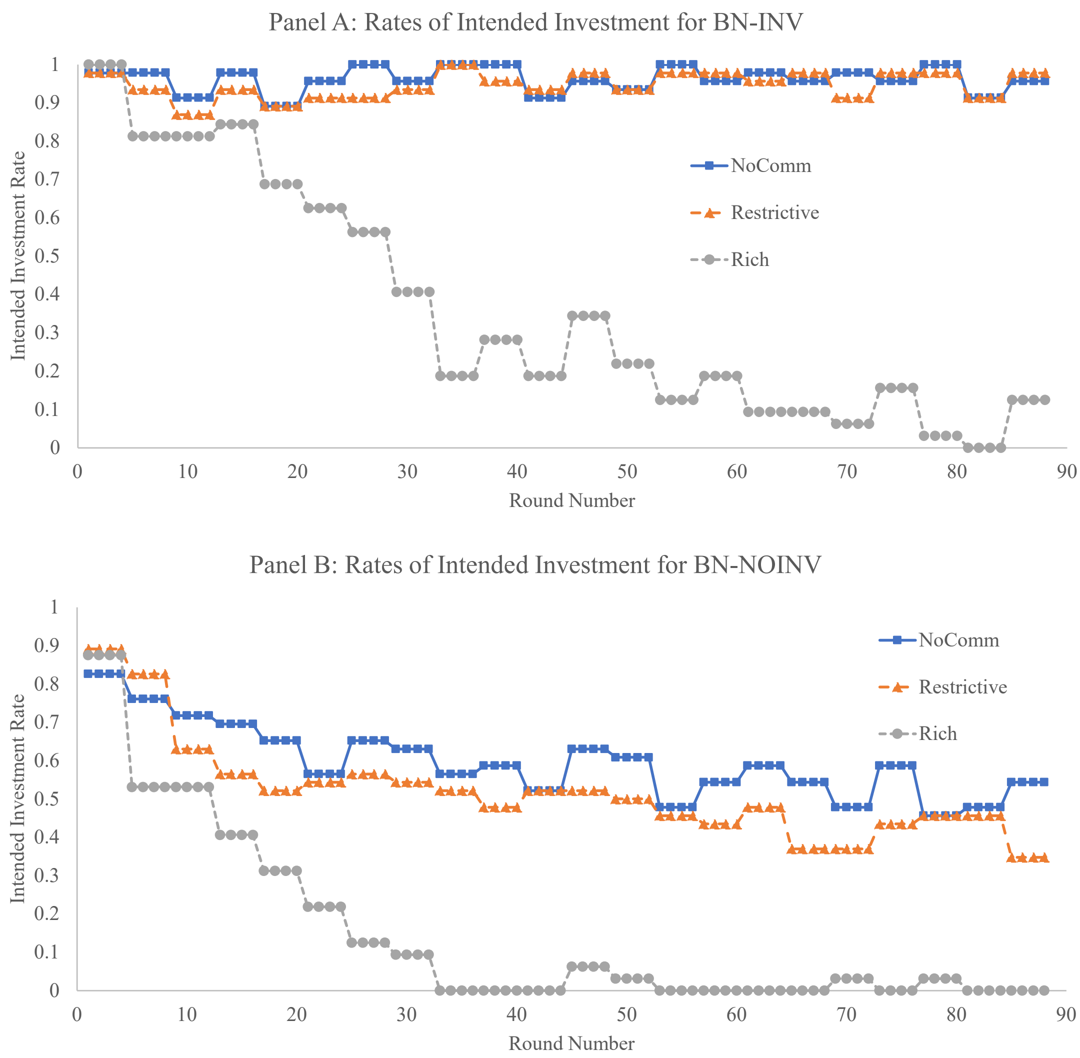
Tables 5 and 6 report panel regressions to compare the intended investment rates statistically, and support our first empirical result. These regressions account for time trends with a round number regressor and interactions, and also include demographic and estimated risk and social preference controls.[11]

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 sets 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

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

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



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.

4.2 Pricing

The realized investment outcomes determined which pricing subgame applied for payoffs realized in 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

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.

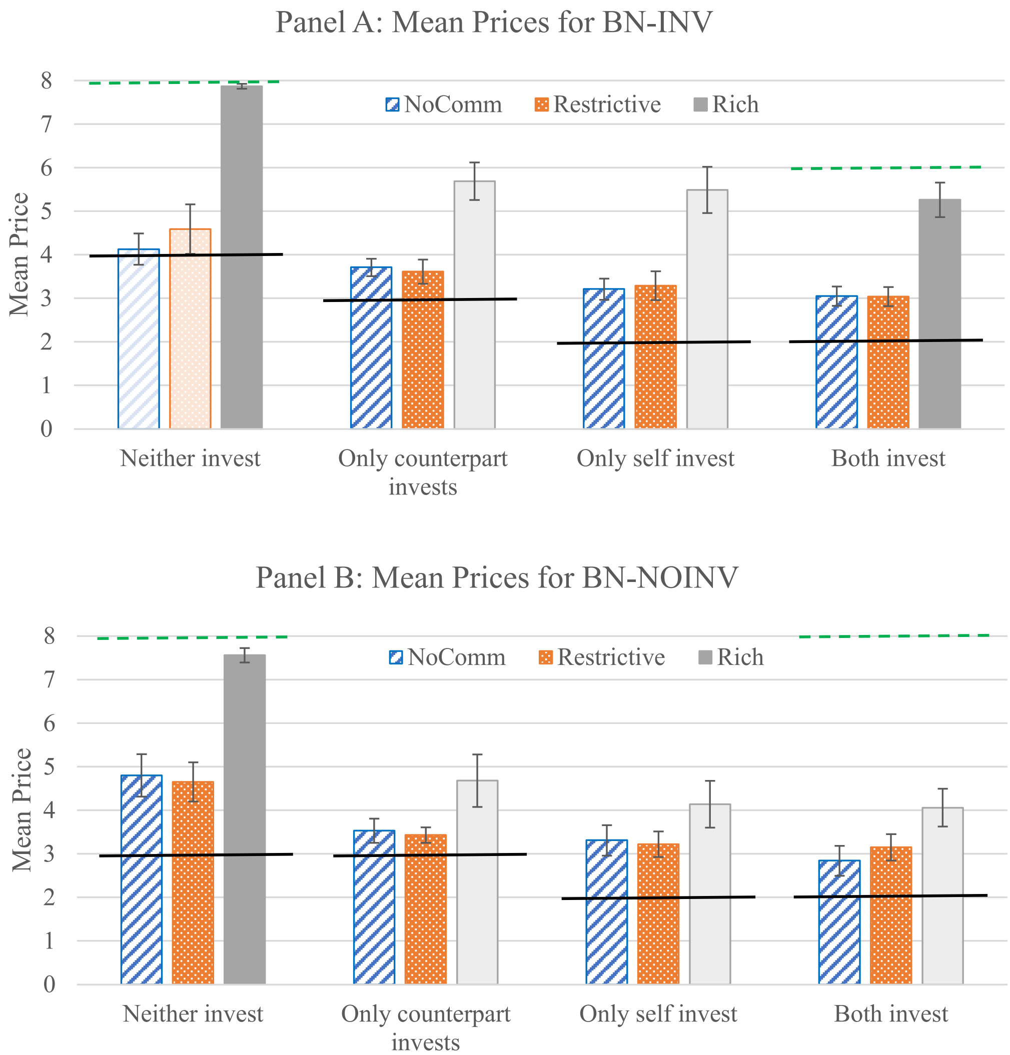
Table 6: Intended Investment Choices – Comparing Parameterization Treatments

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.

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



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

Figure 3 displays the mean price choices across treatments for all four possible subgames. This figure pools across all 88 rounds, since the time trend across rounds either within supergames or across supergames is modest. We therefore relegate price time series figures to the Appendix. This figure summarizes all 21,824 price choices. 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 Bertrand-Nash equilibrium for the static game. 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.

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.[12] Consistent with Figure 3, prices differ little when only restrictive communication opportunities are made available.

Table 8 reports random effects regressions to support the second part of this result. 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

[12]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).

to obviate the concerns about the endogeneity of investment.[13]

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).

4.3 Firm Earnings

Figure 4 displays 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 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 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 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).

[13] 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.

4.4 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

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

	Both vs. Neither Succeed			One Successful Investment		
Panel A: BN-INV	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Parameters	No Comm.	Restrictive	Rich	No Comm.	Restrictive	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	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Parameters	No Comm.	Restrictive	Rich	No Comm.	Restrictive	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

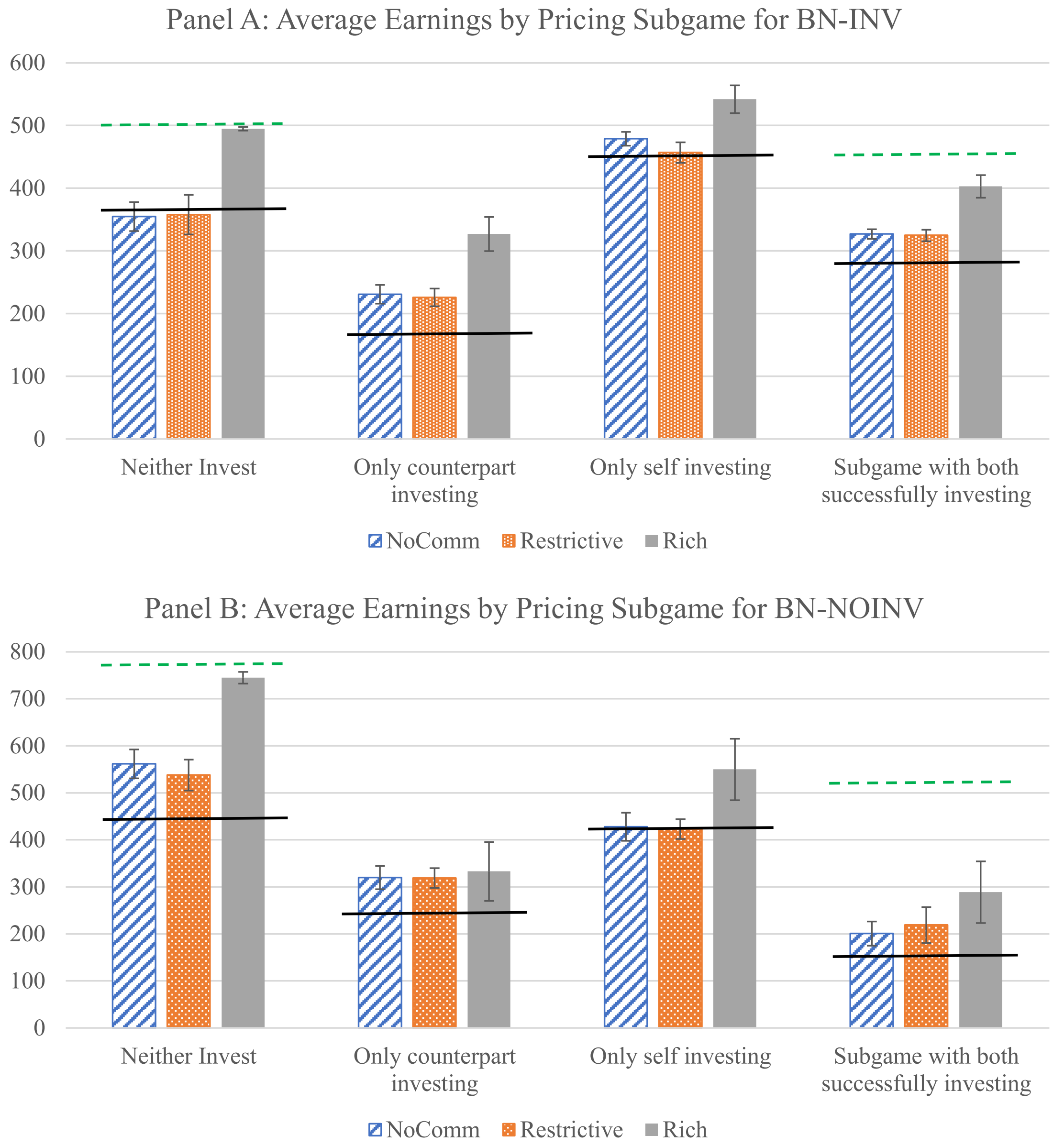
Note: Standard errors in parentheses based on subject random effects. Investment success instrumented using realized stochastic success draws. ***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

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

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.

message that they intended to invest.[14]

For the BN-NOINV treatment, firms tried to invest about half the time. The top part of Table 10 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

[14]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 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.

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).

Table 10: 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

4.5 Consumer Surplus

The CSR investments and firm price choices have direct implications for consumer surplus. As discussed in subsection 2.3, whether consumer surplus increases after investment depends on whether price increases more or less than the representative consumer's additional willingness to pay of 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 11 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 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 the authorities' regulatory responsibility is on utilizing competition policy to shape the

Table 11: 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

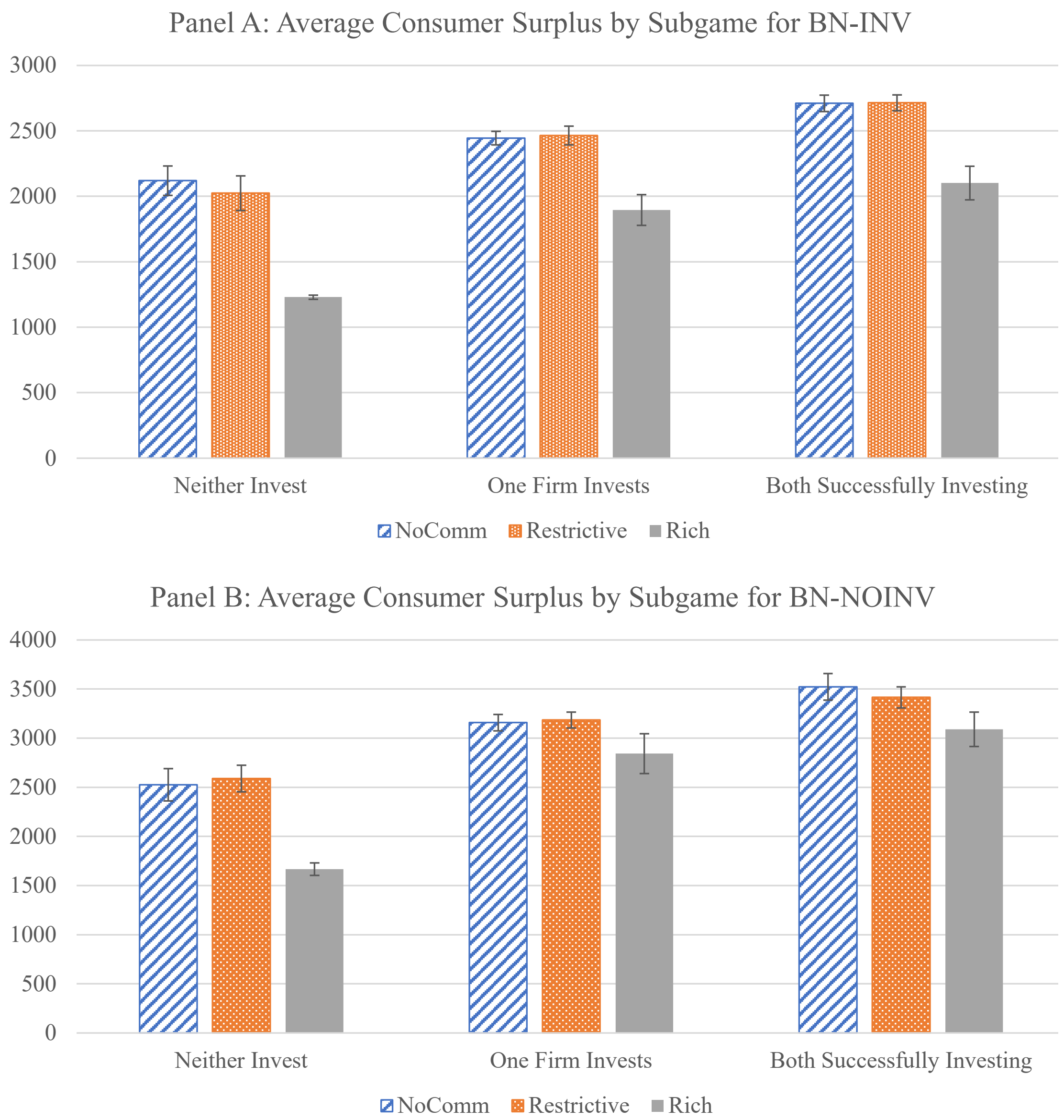
Note: Standard errors in parentheses based on random effects.
***, ** and * denote 2-tailed significance at 1, 5 and 10 percent, respectively.

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 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.

While 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

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



Note: Error bars designate 95% confidence intervals based on clustered standard errors.

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. Given these higher prices, firm profits with rich communication also significantly outweigh 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 investment does not necessarily lead to higher rates of investment; in fact, it may suppress 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 (Treuren and Schinkel, 2018; 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 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.

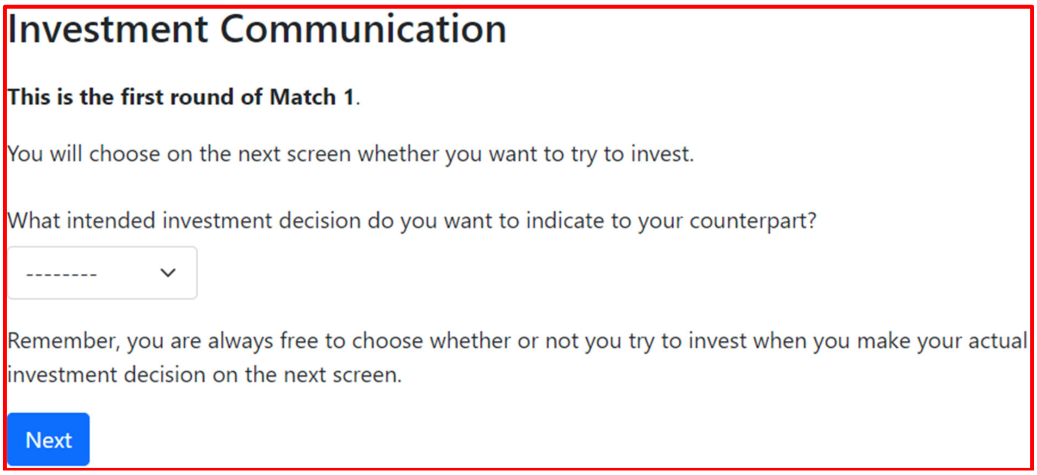
Each producer, including you, has to take an investment decision first and then a sequence of price decisions. The customers who eventually buy your products are simulated by the computer. The rule is: the higher the price of one seller's product compared to the other seller's product, the less products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

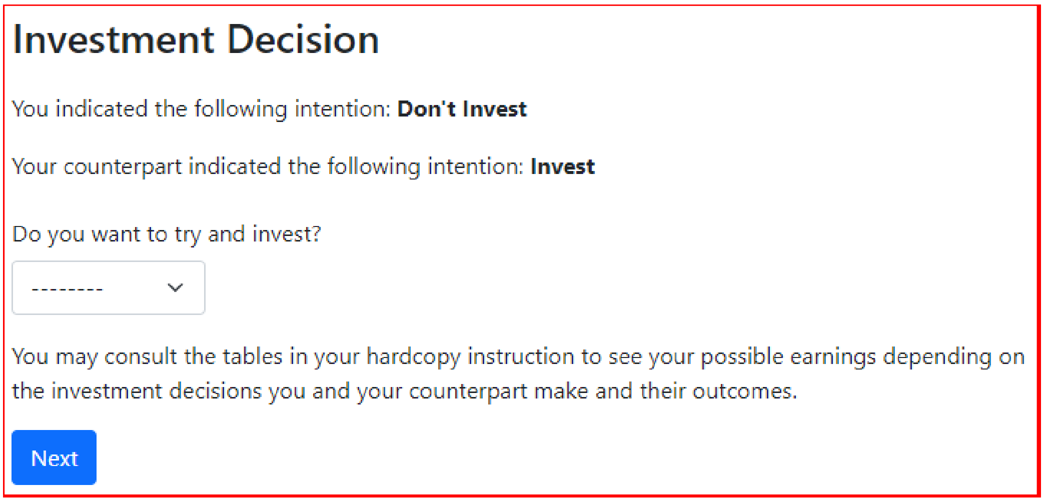
4 rounds, the 2 sellers in each industry will have an opportunity to indicate to their counterpart whether or not they intend to invest for the upcoming rounds. You are always free to choose whether or not you try to invest regardless of what you communicate to your counterpart. This is illustrated in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

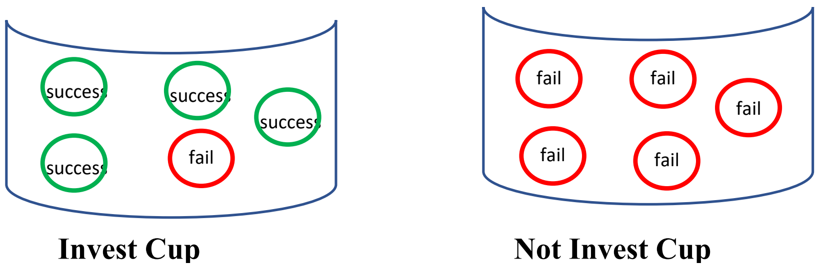
Investment Decision

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

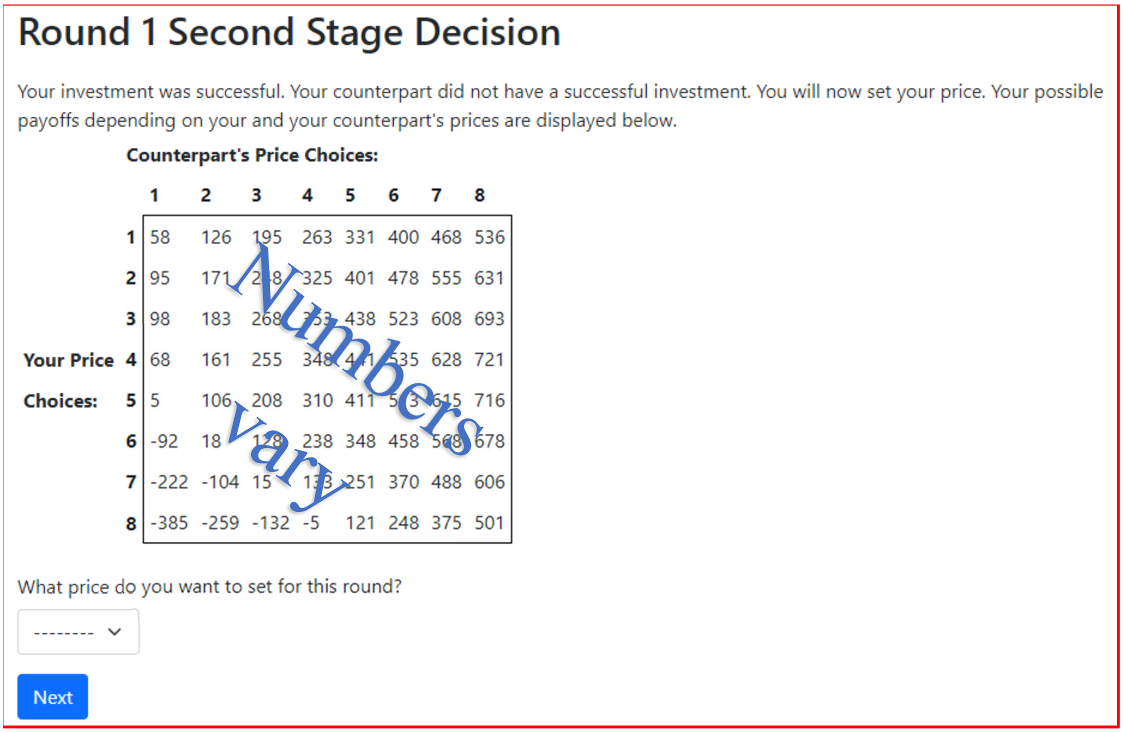
For every combination of investment success (none, one, or both producers choose to invest and are successful), new earnings tables are determined for the following 4 rounds. These are displayed on the last page of these instructions. The entries show your earnings for your price choice (shown in the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

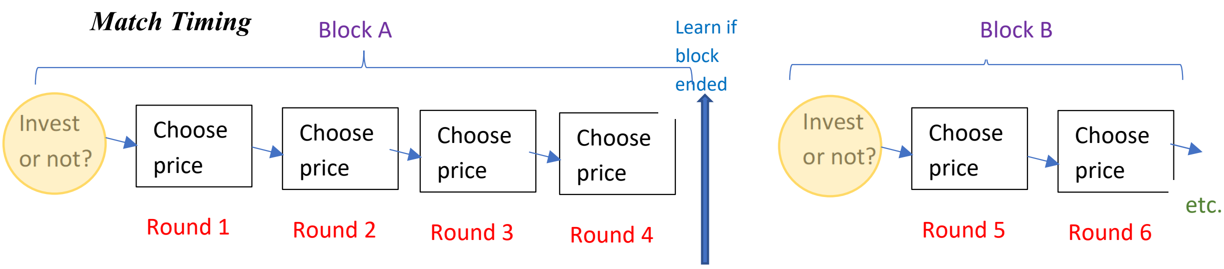
Your investment was successful. Your counterpart did not have a successful investment. You will now set your price. Your possible payoffs depending on your and your counterpart's prices are displayed below.

Counterpart's Price Choices:

Your Price Choices:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	58	126	195	263	331	400	468	536
2	95	171	248	325	401	478	555	631
3	98	183	268	353	438	523	608	693
4	68	161	255	348	441	535	628	721
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

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 12: 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.

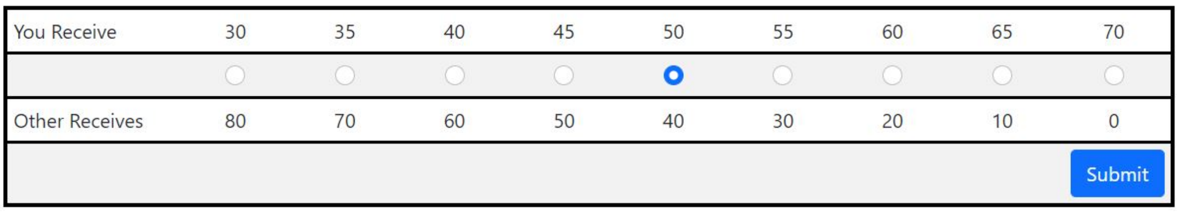
At the end of the experiment, you will be informed of the results of this part: your choice of option, your random number, and your earnings.

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	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

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