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Do Buyer Groups Facilitate Collusion?*

Hans-Theo Normann† Jürgen Rösch‡ Luis Manuel Schultz§

November 2014

Abstract

We explore whether lawful cooperation in buyer groups facilitates collusion in the product market. Buyer groups purchase inputs more economically. In a repeated game, abandoning the buyer group altogether or excluding single firms constitute credible threats. Hence, in theory, buyer groups facilitate collusion. We run several experimental treatments using three-firm Cournot markets to test these predictions and other effects like how buyer groups affect outcomes when group members can communicate. The experimental results show that buyer groups lead to lower outputs when groups can exclude single firms. Communication is often abused for explicit agreements and this strongly reduces competition.

JEL Classification: C7, C9, L4, L41

Keywords: buyer groups, cartels, collusion, communication, experiments, repeated games

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1 Introduction

Lawful joint-market institutions are often abused for the organization of cartels. This has been suspected at least since The Wealth of Nations: the well-known quote (Smith, 1776) that "*people of the same trade seldom meet together ..., but the conversation ends in a conspiracy against the public*" is after all a statement about joint-market institutions—platforms where people of the same trade meet. Recent studies confirm Smith's suspicion. In their meta study, Levenstein and Suslow (2006, p. 69) find that between 25 to 50 percent of the cartels covered in U.S. studies involved trade associations. Schultz (2014) obtains a similar figure for Germany: more than half of all illegal cartels fined by the Federal Cartel Office between 1958 and 2002 used lawful joint-market institutions for their organization.

Antitrust policy is aware of the anticompetitive effects joint-market institutions may entail. Buyer groups, trade associations or industry-wide information systems require an exemption from the general cartel prohibition. While in most cases these exemptions are granted, policy makers know these institutions may be abused. The new EU guidelines on horizontal co-operation agreements (EU Guidelines, 2011, p. C 11/4) point out that "horizontal co-operation agreements may lead to competition problems." This is will be the case if the firms agree to raise prices or reduce outputs. Similarly, the US antitrust guidelines for collaborations among competitors (US Guidelines, 2000, p. 6) mention that competition may be harmed.

At the same time, cartel law emphasizes the advantages joint-market institutions may have. *"Horizontal co-operation agreements can lead to substantial economic benefits* (EU Guidelines, 2011, p. C 11/4). They "*often are not only benign but procompetitive*" (US Guidelines, 2000, p. 1). Consumers may also benefit, so joint-market institutions may well improve welfare. It appears joint-market institutions can lead to cartelization but they can also be beneficial.

In this paper, buyer groups serve as an example for the analysis of the collusive effects of lawful joint-market institutions. Buyer groups are an important and frequent joint-market institution. In a buyer group, downstream competitors purchase their inputs jointly and obtain economies at the procurement level better than individual firms are able to (in Section 2 we discuss the literature on this issue). As with joint-market institutions in general, the pro-competitive effects of buyer groups will typically be proudly advertised, however, much less is known about the dark side of such institutions. Our research aims at shedding light on these collusive effects.

Our first contribution is a novel analysis of the repeated Cournot oligopoly model which highlights two collusive effects of buyer groups. The first collusive effect arises since the buyer group may be abandoned altogether. Since joint procurement brings lower costs for the firms involved, dissolving the group constitutes a more severe but credible punishment strategy. Second, some buyer groups have the power to exclude individual firms from the group. Deviators from the collusive path can be severely and credibly punished this way. Repeated-game arguments hence suggest that such exclusionary buyer groups facilitate tacit collusion even further. The EU Guidelines (2011, p. C 11/45) presume that "incentives for price competition may be considerably reduced" and that buyer groups may "[...] foreclose competing purchasers by limiting their access to efficient suppliers".[1] These points in the guidelines are rationalized by our model. The theoretical analysis confirms the policy makers' worries that buyer groups may reduce the incentive to compete.

The exclusion mechanism introduces an interesting variant to the theory of infinitely repeated games. Usually, both the deviator as well as the cheated-upon players endure low payoffs along the punishment path (this is the case for Nash trigger strategies, optimal penal codes, and other punishments).[2] Exclusion from a buyer group, by contrast, allows for

[1]Another concern listed in the *EU Guidelines* is that buyer groups may reduce the range or quality of the products they produce. The *US Guidelines* also mention potential anticompetitive effects of buyer groups (US Guidelines, 2000, 3.31a). They "may facilitate collusion by standardizing participants' costs or by enhancing the ability to project or monitor a participant's output level through knowledge of its input purchases."

[2]With perfect monitoring, the punishment paths are never triggered, of course. They only serve as a threat. In games with imperfect monitoring (Green and Porter, 1984), the punishment path is occasionally

pinpointed, targeted punishments where the punishing (cheated-upon) players have higher payoffs than the punished players (deviators).

Our second contribution are laboratory experiments which complement the theoretical analyses. We run several experimental treatments in a three-firm Cournot framework. Next to a baseline standard triopoly, we have a 2×2 treatment design with buyer group and communication as the treatment variables. As in the EU Guidelines (2011) and in our theoretical analysis, we introduce two types of buyer groups: either the group can be joined by everyone or the group's rules allow for the exclusion of single firms. Communication, if enabled, allows for free chat via typed messages.

There are several motivations for running experiments in this case and for our specific design:

– First, whether facilitating factors like buyer groups affect market outcomes is an intriguing topic with policy implications. It it is well known that tacit collusion in the laboratory is more or less restricted to two players (Huck et al., 2004). Will the facilitating factor lead to tacit collusion with more firms? Experimental evidence may strengthen the policy makers' worries expressed in the guidelines.

– A second issue where experiments are useful is the impact of communication. We know (see below) that certain types of communication can lead to high levels of cooperation. Here, the issue is whether seemingly innocuous talk at the buyer group level has a collusive effect, or whether such talk is abused for explicit agreements. The EU Guidelines suspect that buyer groups "serve as a tool to engage in a disguised cartel [...]" (2011, p. C 11/45), but this is difficult to verify. Experiments allow for a clear-cut investigation.

– Third, the aforementioned exclusion mechanism is not only interesting from a theoretical perspective. In the experimental literature, Ostrom et al. (1992) and Fehr and Gächter (2000) introduce individually targeted punishments in public-good games,

carried out.

and show that they support cooperation. This has triggered a huge literature which we compare to our results in Section 6.2. Our mechanism is more intricate than the simple punishments in the previous literature. Yet, behaviorally, such punishment may be more likely to be observed. And finally, our experiments are tests of the theory.

Our experimental results show that buyer groups facilitate collusion only if they involve a punishment mechanism to exclude deviating firms. If firms get excluded in our experiments, it is almost always the firm with the highest output (a deviator in the repeated game). By contrast, the threat of abandoning the buyer group altogether does not lead to lower outputs. Communication per se has a moderate collusive effect whereas explicit quantitative agreements on outputs have considerable anticompetitive effects. They can be considered an abuse of the buyer group institution.

2 Literature

We start with the theoretical literature. Closley related to our topic are analyses of the collusive effects of various joint-market institutions. Joint ventures are a prime example. Cooper and Ross (2009) analyze theoretically how joint ventures or strategic alliances between two or more firms in one market can serve to facilitate collusion in another possibly unrelated market. Goeree and Helland (2010) empirically estimate the collusive effect of joint ventures on product market performance. Martin (1995) introduces a model specifically on R&D joint ventures. Schultz (2002) shows that legal cooperation in the form of an export cartel can facilitate collusion in the domestic market. Normann (2001) analyzes exchange agreements where firms "cross supply" goods to competitors who could produce the good themselves. These agreements may save fixed costs, but they also facilitate tacit collusion.

There is also a small literature on the effects of buyers groups. One issue of interest is the analysis of the exact channel through which buyer groups obtain better conditions in procurements (see Ruffle, 2009, for a survey). In Snyder (1996), large buyer groups are able to obtain better purchasing conditions because, in a repeated game, periods of high demand (booms) are more prone to price wars since today's demand is high relative to future demand. See Ruffle (2013) for an experimental analysis of the same setup. A second source of why buyer groups may be able to purchase at better conditions is the curvature of the surplus function; see Normann et al. (2007). Like our paper, Doyle and Han (2009) show that buyer groups have collusive effects but the channel they identify differs from ours. Their paper builds on Shaffer (1991) who shows that firms may soften competition by procuring inputs at higher prices. Higher input prices imply higher output prices, but since increased input costs are refunded from suppliers, firms have higher profits. While this equilibrium breaks down with unobservable contracts, Doyle and Han (2009) argue that buyer groups rectify the problem and cause higher prices again. Related is Salvatore and Miklos-Thal (2012) who find that an implicit agreement on input supply contracts with above-cost input prices and negative fixed fees facilitates collusion on downstream prices.

We next turn to experimental papers on collusion. Since the this literature is large (see the general surveys by Haan et al., 2009, and Potters and Suetens, 2013), we focus on experiments where, as in our case, an additional decision stage precedes the actual market game. Anderhub et al. (2003) analyze the impact of capacity choices on price competition and find not much of a collusive effect. Suetens (2008) examines an experiment where explicit R&D cooperation is possible before price competition kicks in. When firms can credibly commit to an R&D contract, the degree of price collusion turns out to be significantly higher. Nicklisch (2012) investigates advertising and finds that high spillovers between advertising expenditures lead to higher prices, however, only for experienced players.

Our research is further related to previous experiments with communication. This literature is also large and we refer the reader to Crawford's (1998) survey and Balliet's (2010) more recent meta study of dilemma games. Several experiments have shown that communication can improve cooperation in dilemma games. To what extent communication helps depends on the format of the communication. One-sided communication like unilateral price announcements typically loses its impact over time (Holt and Davis, 1990; Cason, 1995) whereas multilateral communication can lead to persistently higher prices (see the posted offer markets with face-to-face communication in Isaac et al., 1984). Crawford (1998, p. 294) argues that multilateral communication has a “reassurance effect” which helps to coordinate on more efficient equilibria. Balliet (2010) finds a positive effect of communication on cooperation where the effect of face-to-face discussion is stronger compared to written messages (see also Brosig et al., 2003).

Other experiments in industrial organization involving communication include Cooper and Kühn (2014) who analyze communication in a two-stage game of conditional cooperation. A cooperation stage is followed by a coordination game, and the credible threat to play a Pareto inferior Nash equilibrium in stage two can theoretically support cooperation in stage one. When unlimited pre-game communication is possible, substantial degrees of collusion occur. Furthermore, experiments on leniency programs typically involve communication and are therefore loosely related to our study (Apesteguia et al., 2007; Hinloopen and Soetevent, 2008; Bigoni et al., 2012).

3 The Model

In our model firms play a linear Cournot game. Before playing that market game, they may establish an input-purchasing group which affects their procurement cost. We consider two variants, the open buyer group and the closed buyer group.

Formally, there are n firms, indexed from $i = 1, ..., n$. Let $q_i \in [0, \infty)$ denote firm i's output. Inverse demand is assumed to be linear $p = \max\{a - \sum_{i=1}^{n} q_i, 0\}$. Firms procure at constant marginal production cost, c_i. Marginal cost can either be low ($\underline{c}$) or high ($\overline{c}$). Hence, firms' profit functions are

$$\pi_i = (\max\{a - \sum_{i=1}^{n} q_i, 0\} - c_i)q_i \tag{1}$$

with $c_i \in \{\underline{c}, \overline{c}\}$.

Firms play the following buyer group-participation game:

(1a) Firms simultaneously decide whether they wish to join the group. If at least $n - 1$

firms join the group, the in-group firms procure at low marginal cost, $\underline{c}$, whereas a firm that does not join procures at high costs, $\overline{c}$.[3] If $n-2$ or fewer firms decide to join, all firms have high marginal cost.

(1b) *(Closed buyers groups only)* Provided all n firms join the group in Stage 1a, firms simultaneously suggest one firm (if any) for exclusion from the group. Only if $n-1$ firms agree to exclude a firm is the targeted firm excluded from the group and has $c_i = \overline{c}$ whereas the other firms continue to have $c_j = \underline{c}$.

(2) Given buyer group participation and cost realization, firms play the n-firm Cournot game.

The proof of the following proposition can be found in the Appendix.

Proposition 1 (one-shot game). *In* open *buyer groups, both establishing a buyer group comprising all firms and not establishing a buyer group can be part of a subgame perfect Nash equilibrium. The same holds for* closed *buyer groups. Moreover,* closed *buyer groups exclude one firm in the subgame perfect Nash equilibria where the group is established.*

The intuition behind this proposition is as follows. Joining the buyer group is a weakly dominant strategy as a firm always benefits from having lower costs. So, one subgame perfect Nash equilibrium outcome has all firms joining the group. If $n-3$ or fewer firms join the group, a firm is indifferent between joining and not joining. Hence, a second subgame perfect Nash equilibrium outcome (in weakly dominated strategies) involves $n-3$ or fewer firms joining the group.[4] This holds for both the open and the closed buyer group. In the

[3] The motivation for this setup is that buyer groups must have a minimum size to be able to procure cheaper than single firms. To allow for outsiders to the buyer groups, we decided not to demand that the entire industry is required to join the group. It is straightforward to extend the model such that groups of size $n-k$, $k>1$, are allowed.

[4] To be precise, there are many pure-strategy equilibria of this type, all of which have $n-3$ or fewer other firms joining the group.

closed buyer group, it pays for any set of $n-1$ firms to exclude one firm. While firms might face a coordination problem of whom to exclude, exclusion is part of the subgame perfect Nash equilibrium.

Consider now infinitely many repetitions of the one-shot game. Time is indexed from $t = 0, ..., \infty$ and firms discount future profits with a common factor δ, where $\delta \in [0, 1)$. To investigate the stability of a possible cartelization of the market, we will look for a subgame perfect equilibrium where firms manage to sustain the symmetric joint-profit maximum by threatening to revert to a static Nash equilibrium in the case of a deviation (trigger strategy). Let δ_0 denote the smallest discount factor required for such a collusive equilibrium.

The analysis of the one-shot game above suggests three different outcomes: in the game without a buyer group ("baseline"), we have standard Nash reversions; for the open buyer group, not establishing a buyer group leads to lower profits because firms have high costs; closed buyer groups can exclude in the case of a defection which yields even lower profits for the deviator. Since collusive and defection profits are the same in all three cases, we obtain (see the Appendix for details):

Proposition 2 (repeated game). *For the minimum discount factor required to sustain the joint-profit maximum as a subgame perfect Nash equilibrium with Nash reversions*

$$\delta_0^{baseline} > \delta_0^{open\ buyer\ group} > \delta_0^{closed\ buyer\ group}$$

holds. That is, open buyer groups facilitate collusion, and closed buyer groups facilitate collusion more strongly than open buyer groups.

Note that the proposition does *not* depend on the assumption that firms attempt to achieve the joint-profit maximum (see Appendix). What our result does depend on is the assumption of trigger strategy reversions to a static Nash equilibrium.

4 Design and Hypotheses

We want to assess the collusive impact of buyer groups along two dimensions. One dimension is that buyer groups allow for more severe punishment strategies than standard oligopolies, as in points 201 and 203 of the *EU Guidelines*. Hence, we have the treatments exogenous buyer group (Baseline), open buyer group, and closed buyer group. The second dimension is that buyer groups legally enable communication between firms. This communication may be used for collusive agreements ("cartel in disguise"). Here, we have the variants Talk and NoTalk. Table 1 summarizes the treatment design.

Treatment	Baseline	Open_NoTalk	Closed_NoTalk	Open_Talk	Closed_Talk
Cost	$\underline{c}$	$\underline{c}$ or $\bar{c}$	$\underline{c}$ or $\bar{c}$	$\underline{c}$ or $\bar{c}$	$\underline{c}$ or $\bar{c}$
Buyer Group	exogenous	open	closed	open	closed
Communication	no	no	no	yes	yes
Stage 1	-	entry	entry	entry	entry
Stage 2	-	-	-	chat	chat
Stage 3	-	-	exclusion	-	exclusion
Stage 4	quantity	quantity	quantity	quantity	quantity
# Participants	27	36	36	33	36

Table 1: *Treatments*

The communication treatments were designed as follows. Subjects were allowed to communicate with one another for 40 seconds in every period of the experiment via typed messages, using an instant-messenger communication tool. Subjects were free to post as many messages as they liked, but they were not allowed to identify themselves or post offensive messages. Subjects were aware that their communications addressed the whole group; addressing individual group members or subjects outside the group was not possible.

The limit of 40 seconds was sufficiently long for the communication phase as most talk ended before the 40-second period was over. Subjects were only allowed to communicate at the buyer-group stage. The instructions (see the Appendix) regarding this point read "you are free to talk about whatever you wish, however, you must not explicitly agree on targets regarding the output decisions". We chose this implementation because it is relatively close to Article 101 of the European Treaty of Rome (which prohibits explicit agreements between firms that restrict competition) and Section I of the Sherman Act (which has a similar content). It is clear to subjects that communication about output targets is possible but not allowed.[5]

The Closed treatments are considerably more complex. One reason is that the group participation decision plus exclusion decision preceded the output decision. In the first period, players had to decide whether to exclude a firm even before playing the quantity game. We therefore decided to begin the Closed treatments with seven rounds of the Open buyer group treatment. After the seven rounds, the Closed buyer group mechanism was introduced and used for the rest of the game (see below). In order to account for the restart effect implied by this design, we also began with seven rounds in Open and Baseline, although the treatment was not changed after the initial phase in these variants. The seven periods were announced in the introduction and we paid subjects for them. Below, we only report the data after the seven initial rounds.[6]

[5]This is also the reason why we did not conduct a second baseline treatment with communication. Absent a buyer group decision, it would be implausible to allow for communication which, however, must not concern output decisions. Moreover, even in the Open_Talk treatment, it is trivial to discuss the decision to join (in fact, almost all subject always do so). An additional treatment without the buyer-group decision would not yield any additional insights.

[6]We dismissed the option of implementing a cartel authority in the lab. A cartel authority which investigates with a certain probability and imposes fines according to a set of rules would have complicated our design without adding any further insight into our main analyzed issues. While several laboratory experiments on leniency (Apesteguia et al., 2007; Hinloopen and Soetevent, 2008; Bigoni et al., 2012) have

The buyer-group decisions were implemented exactly as described in the model section. In the *open buyer group*, firms simply decide whether they wish to join the group. In the *closed buyer group*, firms first decide whether to join the group and, given that all firms join, firms decide whether they wish to exclude a firm (if any).

The Cournot oligopoly model was employed with the following parameter values

$$n = 3, \quad a = 130, \quad \underline{c} = 10, \quad \overline{c} = 22. \tag{2}$$

At least three firms are needed to create buyer groups with the option of exclusion. Collusive outcomes without communication do typically not occur with more than three firms (Huck et al., 2004), hence $n = 3$ gives us a good chance to observe treatment effects. We chose the difference between $\underline{c}$ and $\overline{c}$ to be salient, such that being part of the group or being excluded from it has a sound effect on participants' payoffs. On the other hand, the difference should not be too big such that an excluded (or non-joining) firm still procures $\overline{q}^N > 0$. This is the case with $\underline{c} = 10$ and $\overline{c} = 22$.

All treatments were implemented as a repeated game (fixed-matching scheme). After the initial seven periods, there were at least 20 periods in all treatments. From the 21^{st} period onward, a random stopping rule determined whether the experiment would go on or would stop. The continuation probability was 2/3. The actual number of periods were not determined ex ante and thus differed between sessions (between 21 and 28 periods).

The feedback was as follows. Subjects were in every period informed about the buyer

successfully conducted experiments with such a cartel authority in the lab, such a design faces several difficulties in our case. One difference is that subjects in the leniency experiments explicitly choose to communicate, knowing they may be penalized. In the case of communication in a buyer group, the opportunity to talk is always there, and it is legal; only certain content is illegal. This, however, requires the experimenters to actively monitor the communication content and intervene immediately in any period of violation. This may contradict the notion of participant anonymity. Also, given that up to 24 subjects simultaneously produce chat content (which can be rather cryptic), such immediate on-screen content analysis and intervention does not seem practical.

group participation decisions. In the open buyer group treatments, subjects were told, for example, "all firms decided to join the buyer group. All firms have low cost in this period," and similarly if one firm did not join. For the closed buyer groups, an additional feedback was given, for example, if firm 3 was excluded, "firm 1 and firm 2 are still in the buyer group." Subjects were eventually informed about quantity choices and profits.

We now turn to the numerical predictions for the parameters of the design. For the δ_0 of the repeated game, we obtain

$$\begin{aligned} \delta_0^{\text{baseline}} &= 0.57 \\ \delta_0^{\text{open buyer group}} &= 0.50 \\ \delta_0^{\text{closed buyer group}} &= 0.35 \end{aligned} \tag{3}$$

Table 2 states the static Nash equilibria and the symmetric joint-profit maximizing outcome.

output	$\underline{q}^C$	$\underline{q}^N$	$\overline{q}^N$	$\underline{q}^E$	$\overline{q}^E$
	20.0	30.0	27.0	33.0	21.0
profit	$\underline{\pi}^C$	$\underline{\pi}^N$	$\overline{\pi}^N$	$\underline{\pi}^E$	$\overline{\pi}^E$
	1,200	900	729	1,089	421

Table 2: *Benchmarks. Note: "C" refers to the collusive (joint-profit maximizing outcome), "N" is the symmetric low- and high-cost static Nash equilibria, and "E" refers the static Nash outcome where one firm is excluded.*

Regarding the impact of buyer groups on collusion, we follow the common interpretation that a lower minimum-discount factor makes collusion easier.[7] Proposition 2 and the δ_0 in (3) imply

[7]Note that the discount factor implied by the termination rule (2/3) is higher than all δ_0 in (3). This suggests that, theoretically, players can sustain the joint maximum in all treatments. Our hypothesis is based on the observation that play in experiments depends on the magnitude of the punishment payoffs in

Hypothesis 1. *(a) Buyer groups facilitate collusion. (b) Closed buyer groups are more collusive than open buyer groups.*

Communication may help to coordinate on a collusive equilibrium (see Crawford and Sobel, 1982; Farrell and Rabin, 1996; Cooper and Kühn, 2013). In repeated games, there are many collusive equilibria and therefore firms face a coordination problem. Cheap talk can enable firms to coordinate on a certain equilibrium (output targets, market shares, and punishment strategies). Thus, we expect communication to have a positive effect on cooperation. This is also consistent with the previous experimental evidence (see our literature survey above).

Hypothesis 2. *Industry output will be lower in the treatments with communication.*

Our hypotheses taken together imply rankings of industry outputs for our treatments. We have two predicted rankings as our hypotheses do not predict a ranking of outputs for Closed_NoTalk vs. Open_Talk. We should either observe

$$Q^{\text{Baseline}} > Q^{\text{Open\_NoTalk}} > Q^{\text{Closed\_NoTalk}} > Q^{\text{Open\_Talk}} > Q^{\text{Closed\_Talk}}$$

or

$$Q^{\text{Baseline}} > Q^{\text{Open\_NoTalk}} > Q^{\text{Open\_Talk}} > Q^{\text{Closed\_NoTalk}} > Q^{\text{Closed\_Talk}}.$$

5 Procedures

The experiment was conducted and framed as follows. In the instructions, subjects were told that they would act as a firm which, together with two other firms, repeatedly serves a market. They were asked to purchase units of a fictitious good. In each period, the number

that it affects the likelihood of collusion in the direction predicted by theory (see for example Rapoport and Chammah 1965). Dal Bó and Fréchette (2011), show that being an equilibrium action may be a necessary condition for cooperation when the supergame is repeated many times.

of units procured was automatically set equal to the number of units sold on the downstream market (no inventory). We told them the input price of the good was either 22 or 10. In Baseline, the input price was 10 throughout.[8] We further described that subjects had the option to "join a buyer group" and how this choice affected their production cost. Next, we described the quantity decision.[9]

After having read the instructions, participants could privately ask questions. Before the start of the experiment, subjects were asked to answer several control questions. Only then did the actual experiment begin.

The experiments were computerized, using Ztree (Fischbacher, 2007). Recruiting was done with the ORSEE (Greiner, 2004) online recruiting system.

The experiments were conducted at the laboratory of the Duesseldorf Institute for Competition Economics (DICE) in 2012 and 2014. In total, 177 subjects participated in sessions with 12 to 24 participants. We have between nine and 12 independent triopoly groups per treatment. (We aimed at two sessions and 12 groups per treatment; if the number of groups in a session was lower due to subjects not showing up, we conducted a third fully-fledged session.)

[8]In order to keep the Baseline treatment comparable to the other treatments, we mentioned in the instructions that "the input price is usually 22" but "since you and the other two firms are in a buyer group" the price is 10. Hence, strictly speaking, Baseline is not a standard triopoly in terms of the frame but takes into account the aspects of buyer groups that characterizes the other treatments. As we will see below, the data in Baseline do not differ from previous three-firm Cournot experiments. Hence, it appears redundant to conduct a further neutrally-framed triopoly treatment.

[9]We told subjects that a higher aggregate output would lower the market price, and that for aggregate output levels of 130 or more the price would be zero. We did not provide payoff tables or further details of the functional forms. Instead, in each round, subjects had access to an on-screen profit calculator. As Requate and Waichman (2011) show, the use of a profit table or a profit calculator yields indistinguishable results in Cournot experiments.

Participants were students from various departments, many from fields other than economics or business administration. The monetary payment was computed by using an exchange rate of 1,500 "points" for one Euro and adding a flat payment of 4 €. Subjects' average earnings were 21.24 € including the flat payment. The sessions lasted between 60 and 90 minutes.

6 Results

6.1 Overview and Main Results

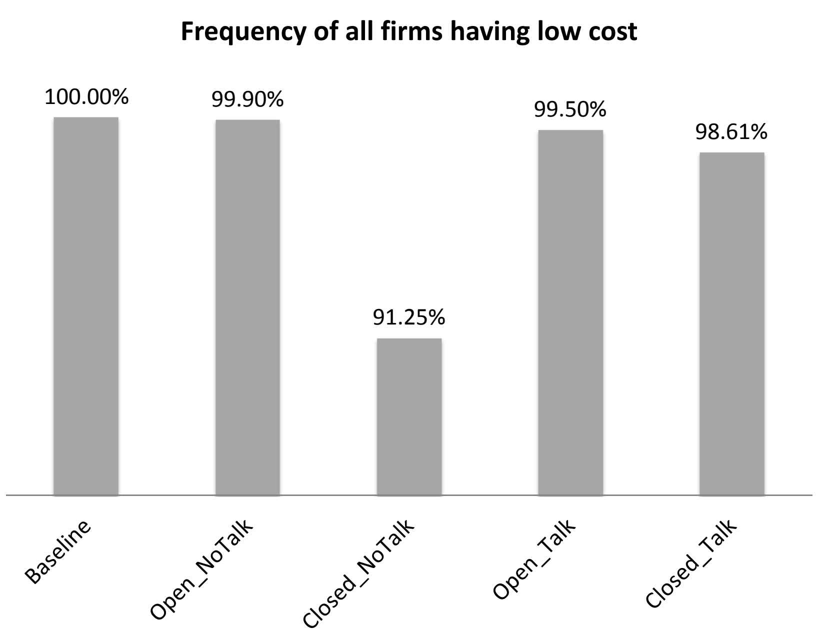

Figure 1: *Frequency of the cases where all firms have low cost. Note that in Baseline, the share low-cost firms is 100% by design.*

Figure 1 shows that almost all firms joined the buyer group in the two Open treatments, as predicted. Firms have low cost virtually all the time, that is, firms joined a buyer group in nearly all cases. This is also true for Closed_Talk. In Closed_NoTalk, the frequency of low-cost outcomes is significantly lower than in the other treatments (rank-sum tests, all $p < 0.001$, two-sided), although the rate is still above 90%. We will cover the issue of who gets excluded and why in Section 6.2.

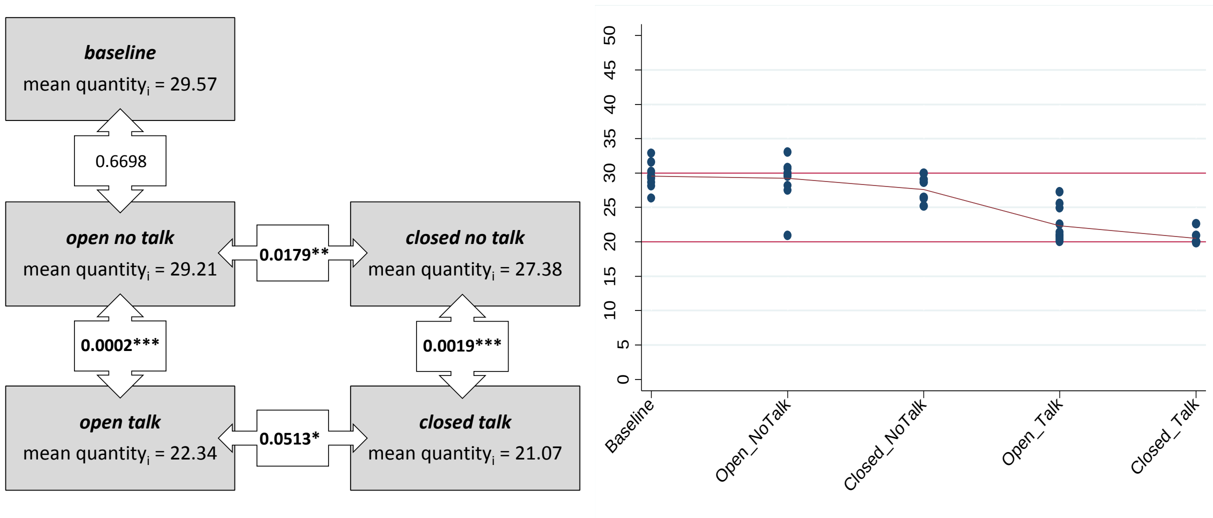

Figure 2: *Left-hand side: Rank-sum tests, p values are two-sided. Right-hand side: Group means across treatments. Note that the static Nash output is 30, joint-monopoly output is 20. Line connects treatment averages. The action space is* $[0, 50]$

.

Next, we take a look at the average outputs. The left-hand side of Figure 2 shows these averages and the results of unrelated-sample ranksum tests (two-sided p values). Average outputs differ significantly and in the direction predicted, except for Baseline and Open_NoTalk which do not differ significantly. The differences between the NoTalk and Talk treatments are highly significant. We observe one of the two predicted rankings of average outputs, so we can reject the null hypothesis that the ranking of average outputs are random.[10] Outputs for the Baseline and Open_NoTalk treatments are rather close to the static Nash equilibrium of 30. Both treatment variables have the predicted effects. Confirming Hypothesis 1, the closed buyer groups cause slightly reduced outputs compared to the open buyer groups. Supporting Hypothesis 2, the possibility of communication in the Talk treatments causes a substantial reduction of output.

The right-hand side of Figure 2 shows the group averages for each treatment. In Baseline and Open_NoTalk, some groups have average outputs above the static Nash prediction, some below (as has been observed by Huck et al. 2004). The other treatments have averages between the static Nash level of 30 and the joint-profit maximizing level of 20. Without communication, only one group managed to sustain an output level close to the collusive level of 20 whereas most groups in Closed_Talk had an average close to 20.

Variable	(1)	(2)	(3)
buyer group	-0.493	-0.493	-0.3551
closed	-1.558**	-1.558**	-1.8319*
talk	-6.585***	-6.585***	-6.8734***
talkclosed			0.5650
period		-0.062**	-0.0623
constant	29.565***	30.219***	30.2187
N	3360	3360	3360
*** 1% level	** 5% level	* 10% level	

Table 3: *Panel regression analysis of firm-level outputs.*

[10] We have five treatments and 5! = 120 possible rankings of average outputs. Two of the 120 rankings are consistent with our Hypotheses. As one of the predicted rankings materializes, we can reject the null hypothesis of random rankings at $p = 2/120 = 0.0167$.

The regressions in Table 3 provide further statistical support for our Hypotheses. We used a random-effects panel estimator and clustered the standard errors at the group level. The *constant* represents the Baseline treatment. The dummy *buyer group* is equal to one in all Open and Closed treatments.[11] Not supporting Hypothesis 1, we find that a buyer group per se does not facilitate collusion, as indicated by the insignificance of *buyer group*. Consistent with Hypothesis 1, *closed* buyer groups significantly facilitate collusion and, consistent with Hypothesis 2, the impact of *talk* is significant and substantial. The interaction *talkclosed* is not significant. A Wald test reveals that *closed* + *talkclosed* is weakly significant ($p = 0.077$), suggesting that the Closed mechanism has a similar albeit weaker impact in the Talk treatments. There is a significant negative trend time captured by the *period* variable which is, however, not very large.

We summarize:

Result 1. Only the Closed buyer groups have significant collusive effects on outputs.

6.2 Closed Buyer Groups

How do firms make use of the possibility to exclude? Table 4 shows that the inclination to suggest exclusion and actual exclusions differ strongly between Talk and NoTalk treatments. While in Closed_NoTalk exclusion was suggested in roughly half of the cases, this figure is only little more than 6% in Closed_Talk. The possibility to talk apparently decreases the willingness or need to exclude a firm from the buyer group.

Recall that exclusions are successful only if two firms suggest the same firm for exclusions. Interestingly, the share of successful exclusions is also lower in Closed_Talk (see Table 4). Whereas in the NoTalk treatment 44.38% of the suggestions to exclude were successful, there were only 27.27% in the Talk treatment (corresponding to six successful exclusions).

[11] If we set the dummy *buyer group* equal to one only when the buyer groups are active, the results are virtually the same.

The higher rate of successful exclusions in Closed_NoTalk is remarkable because firms cannot communicate whom to exclude.

	Closed_NoTalk	Closed_Talk
Exclusion suggested	49.44%	6.11%
Exclusion-suggestion successful	44.38%	27.27%

Table 4: *Suggestions for exclusions and actual exclusions. Rate of successful exclusions are conditional on exclusion being suggested.*

We now turn to the question of who gets excluded. Underlying the repeated-game analysis is that a deviator—a high-output firm—gets excluded in the subsequent periods. The one-shot game would instead suggest that any firm may get excluded because it gives higher payoffs to the excluding firms. The data shows it is the deviators who get excluded. In Closed_NoTalk, we have 79 successful exclusions from the buyer group but these cases distribute only on seven of 12 groups. Among these seven groups, six systematically exclude high-output firms.[12] The sixth group excludes different firms in different periods but, in six of eight cases, these groups exclude the high-output firm. The (seventh) outlier group excludes firms without any apparent system. In Closed_Talk we had six cases of successful exclusion. Three cases occurred in period one and are hence not meaningful in terms of punishment. In the remaining three cases, it was the high-output firm that got excluded:

[12]Further details may be instructive here. Five of the six groups repeatedly excluded one and the same maverick firm in all cases. The maverick firms initially produced more than the other two firms and was then excluded for one or more periods. The deviators in these five groups sometimes reduced their output in response (perhaps because of high costs) but once they are back in the buyer group produced more again which triggers more exclusions. In other cases, the maverick continued to produce high output despite being excluded and having high costs.

that firm produced 30 whereas the excluding firms produced 20.

We complement the descriptive analysis with the probit regressions, using the following variables. Let q_{-imax} denote the largest output produced by i's competitors. The variable $L1.max\{0, q_i - q_{-imax}\}$ then indicates to what extent firm i had the largest output in the previous period; it is zero if i did not have the largest output. Regressor $L1.max\{0, q_{-imax} - q_i\}$ shows by how much firm i's output was below that of the other firms in $t-1$; it is zero if firm i had the largest output in the previous period.

Variable	(1)	(2)
$L1.max\{0, q_i - q_{-imax}\}$	0.069***	0.029*
$L1.max\{0, q_{-imax} - q_i\}$	-0.023	0.054***
excluded $t-1$	1.225***	0.255
excluded_before	0.852**	-0.740**
talk	-1.318**	-2.707**
period	-0.016	0.033**
constant	-2.049***	-1.142**
N	1368	1368
*** 1% level	** 5% level	* 10% level

Table 5: *Panel probit analysis on (1) who gets excluded and (2) who wants to exclude, clustered at the group level.*

Regression (1) in Table 5 shows who gets excluded. Having the largest output in $t-1$ does significantly increase the likelihood of being excluded, consistent with the repeated-game analysis. Furthermore, a firm which was excluded in $t-1$ is significantly more likely to be excluded again in t. This is also consistent with our theory: firms might get excluded repeatedly as a result of a trigger-like strategy. Being excluded at any point before period t

(*excluded_before*) is significant. The impact of *talk* is as expected from the above summary statistics.

Regression (2) in Table 5 analyzes who wants to exclude another firm. Interestingly, $L1.max\{0, q_i - q_{-imax}\}$ is positive and (weakly) significant, that is, the firm with the highest output is more likely to suggest exclusion. This could actually be some counter measure used by a firm when it (correctly) anticipates that it is in danger of being excluded. $L1.max\{0, q_{-imax} - q_i\}$ does also increase the likelihood of wanting to exclude, consistent with our theory. The variable *excluded_before* is negative and significant here.[13] We conclude:

Result 2. In Closed_NoTalk, some groups regularly exclude firms and, if so, it is almost always the deviators who get excluded. In Closed_Talk, exclusion occurs rather infrequently.

Our findings about exclusion in the Closed treatments are consistent with the literature on punishments in public-good games (e.g., Fehr and Gächter, 2000). In the punishment experiments, players can at a cost reduce targeted players' income. In contrast to our game, the punishments cannot be part of an equilibrium in a one-shot game or finitely repeated game. In public-good games with punishment, high levels of cooperation often occur. In our experiments, the effect due to exclusion from the buyer group is only moderate. High degrees of cooperation, however, are not observed throughout in public-good games with punishment (Nikiforakis and Normann, 2007). In the punishment experiments, sometimes the "wrong" players get punished (Cinyabuguma et al., 2006). This is consistent with our data where the high-output firm is more likely (to attempt) to exclude another firm. Finally, our mechanism is probably more complicated, not least since punishment depends on the coordination of two players against one. Altogether, our findings are similar to those of the

[13]We also analyze *how* firms respond to exclusion in their output decisions. Regression analysis (see the Appendix) of outputs in the Closed treatments in Table 7 shows that being excluded (and hence having high costs) strongly and significantly reduces output in all four regressions, as expected. If another firm in the market has been excluded increases output as predicted, although the effect is only moderate. Having been excluded at any point before period t insignificantly increases output.

public-good games with punishment literature.

6.3 The Talk Treatments

The design of the Talk treatments is aimed at two research questions. Do subjects abuse the prohibition of explicit agreements? And: through which channel do they achieve near-perfect collusion?

We analyzed the communication data according to whether there was an agreement, and if so, whether it was about an explicit quantitative target or merely a non-quantitative statement.[14] Specifically, we looked for explicit quantity agreements (e.g., "we should agree on 20"), non-quantitative formulations (e.g., "we should buy less") or no agreement at all. A group was characterized accordingly if at least one piece of communication was a *quantitative* or *non-quantitative* agreement.

Out of the 23 groups we had in the Talk treatments, nine groups (39.13%) made explicit quantitative agreements at least once. All groups made non-quantitative agreements at least once. It appears that buyer groups often abuse the group as a platform for agreements.

To analyze the effectiveness of these agreements we added the data on agreements to a regression on outputs using the dummy variables *quantitative* and *non-quantitative* (see Table 6). If a *quantitative* or *non-quantitative* agreement occurred in period t, these dummies were set equal to one from t until the end of the game.[15] We observe that *quantitative* and *non-*

[14] Note that this analysis deliberately falls short of a full categorical analysis of the chat at the individual or group level (see e.g., Charness and Dufwenberg, 2006; Cooper and Kühn, 2014). We see two problems with this type of analysis in our case. First, we have a repeated game where endogeneity problems will arise. A second problem is that our oligopolies have more than two players. Fay, Garrod and Carletta (2000) suggest that groups with more than two players have a fundamentally different way of communicating than two-player groups.

[15] This seems warranted since communication can have strong hysteresis effects, that is, the effect of communication carries over to non-communication phases of experiments. See Isaac and Walker (1988) and

quantitative have the expected sign; *quantitative* has a larger effect than *non-quantitative* and only *quantitative* is significant. Finally, note that the constant in the regressions is significantly below the Nash benchmark of 30 (Wald tests, specifications (1) and (3) $p < 0.001$, (2) $p < 0.05$). This indicates that communication per se has a moderate collusive effect on outputs even when we control for quantitative and non-quantitative agreements. Scherer and Ross (1990, p. 235-6) mention social factors joint market institutions may bring along—this may be reflected in our data. Quantitative agreements, however, significantly intensify the collusive effect.

	(1)	(2)	(3)
closed	-1.267	-2.405***	-0.935
any		-2.890***	
quantitative			-2.425***
non-quantitative			-1.383
constant	23.113***	25.845***	25.250***
period	-0.074**	-0.065*	-0.006
N	1380	1380	1380

*** 1% level ** 5% level * 10% level

Table 6: *Panel regression analysis of firm-level outputs for Talk treatments, clustered at the group level.*

Result 3. The possibility to talk is regularly abused for explicit quantitative agreements on outputs. These quantitative agreements very effectively support collusion. By contrast, non-quantitative collusive statements do not seem to reduce competition in the markets.

Fonseca and Normann (2012, 2014).

6.4 Welfare

We conclude the discussion of our results with brief remarks on welfare. Assuming all firms procure at low cost, welfare (the sum of consumer and producer surplus) monotonically increases in industry output, Q, as long as $Q \leq a - \underline{c}$. For our model, welfare is given by $Q^2/2+(a-\underline{c})Q$ when $c_i = \underline{c}\ \forall i$. In Figure 1, we saw that, except in treatment Closed_NoTalk, virtually all firms have low costs all the time.

Among our treatments, a social planner would prefer Baseline and Open_NoTalk to the two Talk treatments, and would prefer Open_Talk to Closed_Talk. Closed_NoTalk leads to lower outputs than Baseline and Open_NoTalk which are, moreover, inefficiently procured. Hence, we have a clear-cut policy conclusion against the Closed mechanism and against allowing communication. Since only buyer groups can obtain the cost reduction, treatment Baseline is not feasible for a policy maker (unless he exogenously imposes the buyer group on firms) and Baseline would anyway not imply better welfare than Open_NoTalk anyway. Overall then, Open_NoTalk would be the policy maker's first choice.

7 Conclusion

In this paper, we analyze the collusive effects of buyer groups as an example of a lawful joint market institution. Policy makers are aware that these institutions can be abused for collusion, as reflected in the *US Guidelines on Collaborations Among Competitors* (US Guidelines, 2001) or the recent *EU Guidelines on Horizontal Co-operation Agreements* (EU Guidelines, 2011). Empirically, we know that they often serve as a legal platform for illegal collusion, however, it is unclear just how these platforms are used to cartelize a market.

In our theory section, we show that the mutual dependence in buyer groups facilitates tacit collusion. There are two possible channels. First, the threat to abandon the buyer group altogether reduces the minimum discount factor required. Second, closed buyer groups which have the power to exclude specific firms facilitate tacit collusion even further. The analysis of the closed buyer group is novel in that it allows for individually targeted punishments which cost the deviator more than the punishing firms.

The experimental section of the paper partially confirms these predictions. Buyer groups per se do not facilitate tacit collusion, in contrast to the prediction. Supporting the theory, the possibility to exclude a single firm from the buyer group does result in significantly less competitive quantities. In almost all cases where the exclusion mechanism is used, it is the high-output firms that get excluded. Communication can very effectively support collusion, which is in line with previous experiments (see for example Isaac and Walker, 1984, and more recently Fonseca and Normann, 2012, Cooper and Kühn, 2014, Waichman et al., 2014). Interestingly, communication even has a moderate collusive impact when firms do not abuse the communication stage for explicit quantitative agreements.

Altogether, we confirm the policy makers' concerns with buyer groups. While generally we do not find "reduced incentives" from joint purchasing (*Guidelines*, point 201), we do observe that the possibility to exclude competitors from the access to low input prices is detrimental to welfare (*Guidelines*, point 203). Finally, the *Guidelines* are right to suspect a "cartel in disguise" (point 205) because buyer groups enable communication between firms. Non-exclusionary buyer groups which limit the possibilities to communicate as much as possible are superior from a welfare perspective.

While competition authorities have become more effective at discovering and prosecuting explicit cartels, there has been far less progress with regards to more tacit forms of collusion. An effective policy for dealing with such forms of collusion has been, and will probably continue to be, identifying facilitating practices and either prohibiting them (in cases where there is no legitimate rationale for that practice) or using that practice—along with market evidence of collusion—to prosecute. Our research aims at understanding what those facilitating practices are: how they operate and what to look for are potentially relevant with regards to policy.

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Appendix

Proof of Proposition 1.

Recall that there are n firms. Let q_i denote firm i’s output. Profit functions are $\pi_i = (\max\{0, a - \sum_{i=1}^{n} q_i\} - c_i)q_i$ with $c_i \in \{\underline{c}, \overline{c}\}$.

Stage 2. By backward induction, we solve for the quantity-setting stage first. If all firms are in the buyer group, they have low costs ($c_1 = c_2 = ... = c_n = \underline{c}$) and thus they produce

$$\underline{q}^N = \frac{a - \underline{c}}{n+1} \tag{4}$$

in equilibrium. If no buyer group is established, all firms have high costs ($c_1 = c_2 = ... = c_n = \overline{c}$) and we obtain

$$\overline{q}^N = \frac{a - \overline{c}}{n+1}. \tag{5}$$

In closed buyer groups, there may be one high-cost firm and $n-1$ low-cost firms. We obtain

$$\underline{q}^E = \frac{a - 2\underline{c} + \overline{c}}{n+1}, \quad \overline{q}^E = \frac{a + (n-1)\underline{c} - n\overline{c}}{n+1} \tag{6}$$

where we use the superscript E as it can refer to a buyer group variant where one firm is *excluded*. We use $\underline{q}^E$ and $\overline{q}^E$ for the outputs of the low-cost firms and the high-cost firm, respectively. We assume that cost differences are not too large, so that the high-cost firm still procure a positive amount $\overline{q}^E > 0$.[16] In all cases, Nash equilibrium profits are obtained by squaring the equilibrium outputs. That is, we have $\underline{\pi}^N = \left(\underline{q}^N\right)^2$, $\overline{\pi}^N = \left(\overline{q}^N\right)^2$, $\underline{\pi}^E = \left(\underline{q}^E\right)^2$ and $\overline{\pi}^E = \left(\overline{q}^E\right)^2$. Note that $\underline{\pi}^E > \underline{\pi}^N > \overline{\pi}^N > \overline{\pi}^E$.

[16] The exclusion mechanism can easily be generalized to $n - m$ (low cost) firms who exclude m (high cost, accordingly) firms, $0 \leq m \leq n$. We get $(a - (m+1)\underline{c} + m\overline{c})/(n+1)$, if $c_i = \underline{c}$ and $(a + (n-m)\underline{c} - (n-m+1)\overline{c})(n+1)$, if $c_i = \overline{c}$.

Stage 1b. This stage concerns closed buyer groups only and occurs only if a buyer group was established in Stage 1a. Since $\underline{\pi}^N < \underline{\pi}^E$, $n-1$ firms find it worthwhile to exclude the remaining firm. Thus, in the subgame where all n firms join, the equilibrium involves the exclusion of one firm which then faces high marginal cost. There are n pure-strategy equilibrium outcomes of this type (and possibly also mixed-strategy equilibria), however, firms may face a coordination problem when deciding which firm to exclude.

Stage 1a. Two types of SGP Nash equilibrium outcomes for both the open and the closed buyer group are possible. Either all firms join and have low cost or $n-3$ firms or fewer firms join and all firms have high cost. To see this, note that joining the buyer group is a weakly dominant strategy as a firm always benefits from having lower costs. Specifically, if $n-2$ or $n-1$ of the other firms decide to join, firm i finds it strictly worthwhile to join since $\underline{\pi}^N > \overline{\pi}^N$ and $\underline{\pi}^N > \overline{\pi}^E$; otherwise, i is indifferent. Here, a subgame perfect Nash equilibrium outcome has all firms joining the group and then choosing outputs of $\underline{q}^N$ and earning $\underline{\pi}^N$. If $n-3$ or fewer other firms join the group, firm i is not pivotal and is thus, indifferent between joining and not joining. Hence, a second subgame perfect Nash equilibrium outcome (in weakly dominated strategies) involves $n-3$ or fewer firms joining the group; not joining is a best reply here, and the buyer group is not established. (To be precise, there are many pure-strategy equilibria of this type, all of which have $n-3$ or fewer other firms joining the group.) This completes the proof.

Proof of Proposition 2.

The symmetric *joint-profit maximum* is as follows. The profit maximum can be obtained only if all firms have low costs, thus all firms must join the buyer group and no firm must be excluded.[17] Outputs are

$$\underline{q}^C = \frac{a-c}{2n} \tag{7}$$

and

$$\underline{\pi}^C = \frac{(a-c)^2}{4n} \tag{8}$$

are the profits in the symmetric joint-profit maximum.

Consider now *defection* from the symmetric joint-profit maximizing outcome. The

[17]Note that it does not pay for $n-1$ firms to exclude the n^{th} firm and then collude on outputs. The argument is the same as in the merger paradox of Salant, Switzer and Reynolds (1983), even though the excluded firm has high cost here. For a reasonably low number of firms, we find that $\underline{\pi}^C$ is larger than the profit from colluding among $n-1$ against one high-cost firm playing non-cooperatively.

defecting firm will procure the best reply to $(n-1)\underline{q}^C$ at low cost, which is

$$\underline{q}^D = \frac{(a-c)(n+1)}{4n}, \tag{9}$$

and

$$\underline{\pi}^D = \frac{(a-c)^2(n+1)^2}{16n^2} \tag{10}$$

is the defection profit.

Next, we derive the minimum discount factor required for collusion. Collusion is a subgame perfect Nash equilibrium if and only if

$$\frac{\underline{\pi}^C}{1-\delta} \geq \underline{\pi}^D + \frac{\pi^P\delta}{1-\delta} \tag{11}$$

where π^P is the punishment profit following a deviation. Solving for δ, we obtain

$$\delta \geq \frac{\underline{\pi}^D - \underline{\pi}^C}{\underline{\pi}^D - \pi^P} \equiv \delta_0. \tag{12}$$

as the general minimum discount factor required for collusion.

We will derive δ_0 for three different cases: exogenous buyer group (labelled *baseline*), *open buyer group*, and *closed buyer group*. (i) Baseline is the standard Cournot oligopoly case, so we assume that all firms have low costs here, or that $\pi^P = \underline{\pi}^N$ in this case. It is straightforward to show that

$$\delta_0^{baseline} = \frac{(n+1)^2}{(n+1)^2 + 4n} \tag{13}$$

for baseline. (ii) With the open buyer group, there are two one-shot Nash equilibria as possible punishment strategies: all firms joining is an equilibrium but not setting up the group by not joining is also a subgame perfect Nash equilibrium. Since $\overline{\pi}^N < \underline{\pi}^N$, it follows that $\pi^P = \overline{\pi}^N$ is a credible trigger strategy and a more severe threat than in baseline. (iii) For the closed buyer group, excluding a firm from the group is a static Nash equilibrium and thus a credible threat. Excluding the deviator is firstly the harshest punishment in this case and, moreover, it also resolves the coordination problem of which of the n firms shall be excluded. So we have $\pi^P = \overline{\pi}^E$ here.

We find that collusive (C) and defection (D) profits are the same in all three variants but punishment payoffs (N, E) differ; specifically, we have $\underline{\pi}^N > \overline{\pi}^N > \underline{\pi}^E$. Thus we obtain Proposition 2.

Regression analysis of how firms respond to exclusion in their output decisions.

	(1)	(2)	(3)	(4)
talk	-6.883***	-6.863***	-6.775***	-6.756***
excluded	-5.661**	-5.196**	-5.769**	-5.301*
period	-0.014	-0.025	-0.022	-0.032
other_excluded		0.798*		0.780**
excluded_before			0.797	0.789
cons	28.150***	28.985***	28.041***	27.666***
N	1440	1440	1440	1440
*** 1% level	** 5% level	* 10% level		

Table 7: *Panel regression analysis of firm-level output for Closed treatments, clustered at the group level*

Instructions (translated from the German original).

Welcome to our experiment.

Please read these instructions carefully. Please do not talk to your neighbors and be quiet during the entire experiment. If you have a question, please raise your hand. We will then come to your booth and answer your question personally.

In this experiment you will repeatedly make decisions and earn money. How much you earn depends on your decisions and on the decisions of two other randomly assigned participants. At the end of the experiment, you will get your profit paid in cash.

All participants receive (and are currently reading) the same instructions.

You will remain completely anonymous to us and to the other participants. We do not save any data in connection with your name.

* * *

In this experiment you will have to make decisions for one of three firms in a market. All three firms sell the same product. You have to buy the product from a supplier and then sell it to the customers. In each round, the quantity sold is equal to the purchased amount.

Throughout the whole experiment you will remain assigned to the same two other firms (or to the participants behind the firms, respectively).

All three firms will decide in each round:

1) Do you want to join a buyer group?
2) What quantity of the good do you want to buy?

The 1st decision:

The decision whether to join a buyer group determines the input price you have to pay per unit. Moreover, firms which have opted to join the buyer group are allowed to chat with each other after the first decision.

Through the joint purchase with one or two other firms, you and all other firms in the buyer group receive a discount. A buyer group can consist of two or three firms. One firm alone cannot form a buyer group, and there can be at most one buyer group in the market. In addition:

1. If no buyer group is established, the input price is 22 Talers per unit.
2. If a buyer group with two firms is established, the input price for the two firms in the buyer group is 10 Talers, and 22 Talers per unit for the outside firm.
3. If all three firms join the buyer group, the input price of all firms is 10 Talers per unit.

In each round you will be informed about the decisions of all firms regarding the buyer group (before the second decision).

Chat:

After the 1st decision you will be allowed to chat with the other members of the buyer group. What you talk about is up to you, however, you must not explicitly agree on targets regarding the output decision. The chat ends after 40 seconds.

The 2nd decision:

You have to choose the purchasing and therefore the sales quantity for your firm. This quantity must be between **10** and **50** units.

The following important rule applies. There is a uniform sales price for all firms in the market, which depends on the selected amount as follows; the greater the total amount of all firms, the lower the price you and the other firms receive in the market for the good. With each additional unit brought into the market, the sale price decreases by one Taler. If the total amount of all firms is 130 or above, the sale price is zero.

Your profit per unit sold is the difference between the sale price and the purchase price, which is (as shown) either 10 or 22 Talers. Note that you make a loss per unit purchased, if the sale price is below the purchase price of 10 or 22 Talers. Your total profit per round is equal to the profit per unit multiplied by the number of units sold.

For simulations of your potential profits, we will provide you with a **"Profit Calculator"**, which we will explain in detail before the start of the experiment.

Once all firms have made their decision you will receive a feedback on the quantity decisions of all three firms, the sale price, the profit you have made in this round, and your current total income for the experiment.

***

The experiment starts with **7 rounds**. Then there will be a change and you will receive new instructions.

As **start endowment** you get **6000 Taler**. This endowment will be offset against your profits and losses from all the rounds and at the end of the experiment, you get **1 Euro** per **1500 Talers** of your total income paid in cash.

2nd part of the instructions

From now on, all three firms have to take three decisions in each round, namely:

1) Do you want to join a buyer group? (as before)
2) Do you want to exclude a firm from the buyer group?
3) What quantity of the good do you want to buy? (as before)

You will still be assigned to the same two firms (or to the participants behind the firms, respectively) as before.

* * *

Now, after the chat, it may come to another decision:

If only two firms decide to join the buyer group or in case that no buyer group is established there is **no 2nd decision** and it continues with the 3rd decision as before. If **all three firms** have opted for joining the buyer group it comes to the **2nd decision**.

The 2nd decision:

In the 2nd decision it is possible to exclude a firm from the buyer group. For this purpose, any firm is able to suggest another firm. When two firms suggest the same firm, that firm will be excluded. The cost of firms inside the buyer group will still be 10 Talers per unit produced while the cost of the excluded firm will be 22 Talers. If no firm is excluded, all firms remain in the buyer group.

You will be informed about the exclusion decisions of all firms and will therefore also now your production costs. (Before the 3rd decision)

* * *

From now on, the experiment will last at least 20 rounds. Then, after each round, it is randomly decided if it comes to another round. The computer randomly chooses a number between 0 and 2. When it chooses 1 or 2 another round is played, when it chooses 0 the experiment is over.

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