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The Effects of Private Damage Claims on Cartel Activity: Experimental Evidence*

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Abstract

Private damage claims against cartels may have negative effects on leniency: whereas whistleblowers obtain full immunity regarding the public cartel fines, they have no or only restricted protection against private third-party damage claims. This may stabilize cartels. We run an experiment to study this issue. Firms choose whether to join a cartel, may apply for leniency afterwards, and then potentially face private damages. We find that the implementation of private damage claims reduces cartel formation but makes cartels indeed more stable. The negative effect of damages is avoided in a novel setting where the whistleblower is also protected from damages.

Keywords: *Private damage claims, cartel stability, laboratory experiment, leniency*

JEL classification numbers: *C90, L41, L44*

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1 Introduction

In the airline-cargo cartel case, Lufthansa was the whistleblower and received full immunity from fines, but they were soon after sued privately by Deutsche Bahn for damages amounting to 1.76 billion euros.[1] Would Lufthansa have blown the whistle had they anticipated these damage claims? Do such private damages not provide a strong disincentive to report cartels and apply for leniency? In this paper, we try to answer these questions with evidence from laboratory experiments.

Largely driven by the introduction of leniency programs, cartel authorities can look back at successful years of public cartel enforcement.[2] Leniency policy offers companies involved in a cartel who self-report either total immunity from fines or a reduction in the fines which the authorities would have otherwise imposed on them (European Commission, 2006). As theoretical, empirical, and experimental work shows, leniency policy has a deterrent effect on cartel formation and, as it yields distrust among cartel members, it destabilizes the operations of existing cartels (see, for example, Bigoni *et al.*, 2012; Brenner, 2009; Harrington and Chang, 2009; Miller, 2009; Motta and Polo, 2003; Spagnolo, 2003). For a survey of the research on leniency programs, see Spagnolo (2008).

Damage claims — customers of a cartel may sue convicted wrongdoers for the losses they suffered in civil lawsuits — add an element of private enforcement to anti-cartel policy. Private damage claims have only recently gained attention in Europe. The European Commission started to consider private enforcement with its 2005 Green Paper (European Commission, 2005). It was signed into law in November 2014. In 2018 the last member states implemented the directive on antitrust damages actions into national law (European Commission, 2014, 2018). In the US, private damage claims have existed since the early 20th century. Here, private enforcement is viewed as an important and long-standing antitrust policy tool since public enforcement is restricted to

[1] See Kiani-Kress and Schlesiger (2014) and Michaels (2014). At least initially, private damages far exceeded the total fines of all cartel members which, eventually, summed up to 776 million euros (see European Commission (2017a)).

[2] For example, MAN revealed the EU-wide truck cartel (1997–2011) and received full immunity from the European Commission (EC). Further examples are the vitamins cartel (around 1985–1999) and the air cargo cartel (1999–2006), in which the EC and the US Department of Justice granted full immunity to Rhône-Poulenc, respectively Lufthansa, for revealing the cartel (Department of Justice, 2007, European Commission, 2001, par. (124), 2016, par. (31), 2017b, par. (28)).

litigation in order to impose fines on cartel members (Canenbley and Steinvorth, 2011).[3] Despite these differences in the duration of application, private damages now constitute an important dimension of cartel policy in both the EU and the US.

At first sight, it seems that private damage claims nicely complement public enforcement. They raise the expected penalty for forming a cartel and therefore add to the deterrent effect of the fines imposed by antitrust authorities. Becker (1968) argues that increased sanctions decrease criminal activity.[4, 5] Private damage suits constitute an additional sanction and should accordingly reduce the criminal activity of explicit collusion.

There are, however, growing concerns about the negative effects of private enforcement. As the Lufthansa example shows, the detrimental impact that compensation payments for damaged parties have on the attractiveness of leniency programs are evident. Whereas penalties are waived or reduced for cooperating leniency applicants, the European Damages directive gives only limited protection against third-party damage claims (European Commission, 2014).[6] The effect is aggravated by the fact that cartel members are jointly liable for the entire damage caused by the cartel, and compensation payments are not capped, in contrast to fines which may not exceed 10% of annual turnover (European Commission, 2011). With respect to private damage claims, the European legislation restricts the liability of leniency applicants to the harm caused to their own direct and indirect purchasers. In any event, applicants remain fully liable when non-applicants are not able to entirely compensate the injured parties (European Commission, 2014, par. (38)). In comparison, the US antitrust law limits the liability of leniency applicants to single, instead of treble, damage compensation payments (Antitrust Criminal Penalty Enhancement and Reform

[3]Private damage claims account for 90 to 95% of US cartel cases (Knight and Ste. Claire (2019)). US law incentivizes private lawsuits, for example, by making the infringer liable for treble damages and by admitting class action suits (Clayton Act, section 4, 15 U.S.C. 15; Jones, 2016).

[4] More recently, Bigoni *et al.* (2015) and Chowdhury and Wandschneider (2018) provide experimental evidence of the deterrent effect of penalties on cartels. See also below.

[5] An additional point in favor of private damages, raised by Knight and Ste. Claire (2019), is that private damages can reduce the profitability of sustained collusion. Cartels are no longer monitored by time- and money-constrained competition authorities only, but also by possible private plaintiffs. A higher detection probability reduces the profitability of a cartel, accordingly. This argument is also supported in the work by Lande and Davis (2011).

[6] We will henceforth take a European perspective of this issue in that an existing leniency program was possibly weakened by the introduction of private damages. In the US, private damages predate leniency programs and so the existing anti-cartel policy was strengthened by the introduction of leniency. Nevertheless, the trade-off due to private damages also applies to US antitrust policy. This trade-off, however, might be weakened due to the US antitrust law's limitation of the leniency applicant's liability to single, instead of treble, damage compensation payments.

Act of 2004, Sec. 213).

The literature appears to largely acknowledge this artificially created trade-off between private damage claims and public leniency programs. Canenbley and Steinvorth (2011), Cauffman and Philipsen (2014), Hüschelrath and Weigand (2010), Knight and de Weert (2015), Migani (2014), Wils (2003), Wils (2009) argue informally, and Kirst and van den Bergh (2016) formally, that it is less desirable for firms to apply for leniency when they are liable for private damage claims. The higher the expected third-party claims, the lower the incentives to apply for leniency. As this is also anticipated by other cartel members, it could have a stabilizing effect on cartels. This raises the question of whether applying for leniency remains attractive after the introduction of private damage claims. In the thus far most elaborate theoretical treatment of private damages in cartel cases, Buccirossi *et al.* (2020) argue that the conflict between private damage claims and public leniency programs is only apparent, and that limiting the cartel victims' rights to claim their losses is not necessary. They demonstrate that damage actions will even improve the effectiveness of leniency programs provided the civil liability of the whistleblower is minimized. We return to this important point below.

In the end, whether private damage claims strengthen or weaken the deterrence effects of public enforcement is an empirical question. On the one hand, higher fines should increase deterrence. On the other hand, they may render leniency ineffective. Somewhat surprisingly, we have not been able to find any sound empirical assessment of the effects of private enforcement. Figure 1 shows the number of EU cartel cases since 1990. Cartel cases rose sharply in 2000–2004 with the introduction of leniency programs but they are now in decline. This recent drop in cartel cases coincides with the EU's introduction of private damage claims in 2014. Could this decline have been triggered by private damages? The descriptive numbers in figure 1 cannot identify a causal effect of private damages as many factors are uncontrolled for; foremost, because there are no undetected cartels in the sample.

We propose an experimental approach to study the effects of private damages empirically. Laboratory experiments present a readily available testbed which is unaffected by the sample-

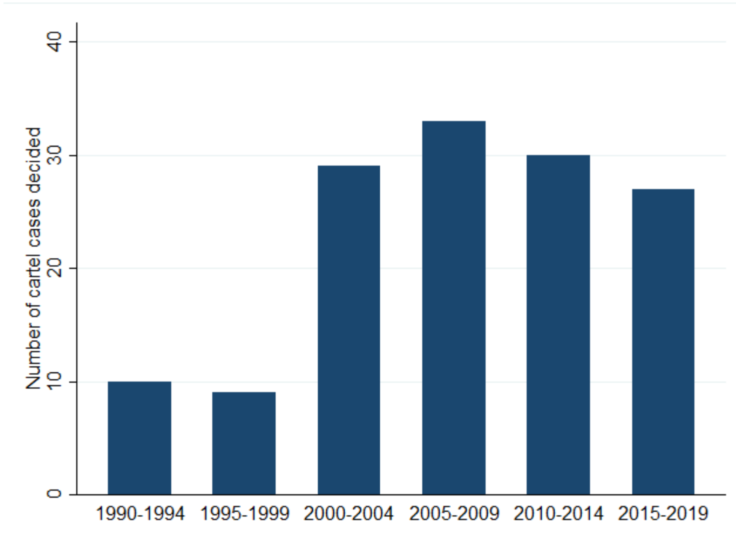


Figure 1: Cartel cases decided by the European Commission 1990–2019. Source, European Commission (2020, section 1.9).

selection problems, which may bias field-data studies. Bigoni *et al.* (2012) mention that it is difficult to evaluate the deterrent or stabilizing effects of antitrust policies compared to other law enforcements because the number of cartels and changes in cartel formation is unobservable.[7] Experiments can be a useful instrument for the evaluation of new policy tools and for analyzing the effects of cartel stability *ceteris paribus*.

We build on – and extend – an established experimental literature on the effects of leniency programs. Apesteguia *et al.* (2007) examine the effect of leniency programs in one-shot Bertrand games. They find that the implementation of the leniency rule tends to increase self-reporting and decrease cartel formation, and leads to significantly lower market prices. Bigoni *et al.* (2012) and Hinloopen and Soetevent (2008) analyze the repeated Bertrand game. The main result of this literature is that the introduction of leniency leads to a reduction in cartel formation.[8] The effect of private damage claims on leniency programs has not yet been studied.

[7]See Miller (2009) and Harrington and Chang (2009) for empirical identifications of policy effects on the number of detected cartels or cartel duration.

[8] Hinloopen and Onderstal (2014) study the effects of leniency on bidding rings in auctions. Bid-rigging is also analyzed in Luz and Spagnolo (2017) with a novel focus on the effect of corrupt officials involved in the cartelization. Feltovich and Hamaguchi (2018) find that leniency also has a pro-collusive effect due to the lower cost of forming a cartel. This effect is, however, offset by firms' reporting, so the overall effect on collusion is negligible. Clemens and Rau (2018) investigate leniency policies that discriminate against ringleaders and find that this, paradoxically, stabilizes collusion. Andres *et al.* (2021) add an innovative element to the experimental leniency literature by having participants play the role of the cartel authority. In a cartel experiment without leniency, Gillet *et al.* (2011) investigate how the managerial decision-making process affects cartel formation and pricing.

Besides showing that leniency improves cartel policy effectively, the experimental literature has made further advances. While Bigoni *et al.* (2012) and Hinloopen and Soetevent (2008) differ in various elements of the experimental design (number of firms, product differentiation, and number of supergames), the most important improvement in the experimental design is that Bigoni *et al.* (2012) allow deviators to report the cartel even before all prices are announced (and not only after). In contrast to Hinloopen and Soetevent (2008), a "deviate and report" strategy before other cartel firms observe the deviation becomes feasible. This is also the case in the field, and it has the advantage that the deviating firm becomes the first leniency applicant and thus receives full immunity. This strengthens the incentives to deviate. Bigoni *et al.* (2012) show in their data that this is empirically the case. In their leniency treatment, deviations are usually combined with a secret report, and reporting rates are much higher. (See also section 2 below.)

Beyond introducing private damages, we extend the literature by comparing structured and free chat-like communication between participants. Some experiments analyze structured communication in the form of price announcements among players where subjects have boilerplate messages available (Bigoni *et al.*, 2012; Hinloopen and Soetevent, 2008). In the context of cartels, both structured communication and chat seems plausible. Cheap talk is recognized as an important tool for the coordination of cooperative outcomes in experiments (Blume and Ortmann, 2007; Camera *et al.*, 2011; Cooper *et al.*, 1992). In the field of antitrust, experiments identify this kind of chat as a powerful device for fostering collusion (Kruse and Schenk, 2000; Cooper and Kühn, 2014; Fonseca and Normann, 2012; Waichman *et al.*, 2014). While the comparison of chat to structured price announcements has been made for collusion experiments without leniency (recently, Harrington *et al.* (2016)), it seems promising to conduct this comparison with the inclusion of leniency. Likewise, Apesteguia *et al.* (2007) and Dijkstra *et al.* (2020) conduct leniency experiments with chat communication but do not compare to non-chat forms of communication.[9]

Our experiment is designed to analyze the effects of private damage claims on leniency applications, cartel formation, and cartel stability. We have the following main research questions.

[9] Landeo and Spier (2009) demonstrate anticompetitive effects of chat-like communication in the context of exclusive dealing.

First, do we observe fewer cartels being established following the introduction of private damage claims? Second, is there a decreasing rate of leniency applications due to private damages? Third, what is the overall balance in terms of cartel prevalence?

The experimental design is largely based on Apesteguia *et al.* (2007), Bigoni *et al.* (2012) and Hinloopen and Soetevent (2008). Subjects play a repeated homogeneous-goods Bertrand triopoly game. They decide whether they want to engage in collusive behavior by communicating about prices, and we vary the communication format available to subjects. We investigate settings with and without private damage claims.

Our first set of results – that are based on a comparison of exisiting private damages to a benchmark in which damage claims are not present at all – is as follows: We show that cartel formation at the individual and the group level is significantly lower with private damage claims. When private damage claims apply, leniency applications decrease notably (although not significantly) and, therefore, cartels seem to be more stable. Overall, the balance is positive as there is an altogether significantly lower level of cartel prevalence. The effect on consumer welfare depends on the form of communication. Private enforcement significantly decreases average prices and therefore increases consumer surplus when communication is structured. Intriguingly, we find the contrary welfare effect in a treatment with chat communication, that is, prices tend to increase, although not always statistically significantly so.

Can the situation be improved, or are the detrimental effects of private damages unavoidable? Buccirossi *et al.* (2020) show in a theory paper that improved legislation can help, such that damage actions will improve the efficacy of leniency programs.[10] It is not necessary to limit the cartel victims' rights to claim their losses. Buccirossi *et al.* (2020) point out that the Hungarian Competition Act (in the 2009 version, predating the EU 2014 directive) ensured that the immunity recipient was liable for compensating the cartel's victims only if the other cartel firms were unable to do so. In theory, this destabilizes collusion (<u>**increases**</u> **the minimum discount factor required for collusion**). That is, private damages (if treated in this manner) strengthen (rather than weaken)

[10] Already Spagnolo (2003) argues that leniency programs can be optimal only if they protect a reporting firm from being sued for damages.

public enforcement. [11]

In an important extension of our experiment, we show that this hypothesis turns out to be empirically sound. We run an additional treatment in which the first leniency applicant is fully protected from damage claims; the other cartel members are liable. Our data confirm that leniency and damages can be complementary tools that reinforce cartel deterrence and maintain leniency incentives under this assumption. This confirms the theory of Buccirossi *et al.* (2020) and gives a first hint that the conflict based on the current EU legislation between leniency and damages can be removed by a change in the design of this legislation.

The article is organized as follows: The subsequent section describes the experimental design and explains the treatments in detail. Section 3 presents our hypotheses which are the basis for our further analyses in section 4. Section 5 provides insights of an additional treatment that protects the leniency applicant from damage suits. We conclude in section 6.

2 The experiment

We choose to study a design that is close to the one incorporated by the EU Directive (European Commission, 2014). This is only one of numerous designs that could be studied. Variations could concern disclosure rules or liability (see Buccirossi *et al.*, 2020). Chapter 5 presents one possible variation in the liability for damage claims.

2.1 General setup

The market model underlying the experiment is a symmetric three-firm homogeneous-goods Bertrand oligopoly.[12] Demand is inelastic and $\{101, ..., 110\}$ is the choice set of prices. Firms have constant marginal costs of $c = 100$. There is repeated interaction: the three players are grouped

[11] Another important topic in this regard is the access to leniency statements and documents. The EU Directive states that national courts cannot impose disclosure of leniency statements and settlements (art. 6[6]). In addition, member states need to ensure that evidence of both categories is either deemed inadmissible in cartel damage suites or is protected according to national rules (art. 7(1)).

[12] Dufwenberg and Gneezy (2000) show that the Bertrand solution is viable for randomly rematched markets with three and four firms but not for two. Huck *et al.* (2004) find that repeated Cournot markets with four or five firms do not behave collusively. See also Roux and Thöni (2015) for a more recent study.

together in one market for the entire duration of the experiment (at least 20 periods).

In our experiment, firms can form cartels, report any existing cartel to a fictitious cartel authority in order to get immunity due to leniency, and may face penalties and private damage claims. Our treatments vary with the implementation of private damage claims and the form of communication. The sequence of events in our experiment is as follows:

1. Decision whether to form a cartel; if all firms agree, communication is enabled and (non-binding) agreements on prices are possible,

2. Price decision,

3. Decision whether to report a cartel; unreported cartels may be detected by the cartel authority; in either case a fine is imposed,

4. Private damage claims.

As mentioned in the introduction, Bigoni *et al.* (2012) allow for both "secret reports" (right after the price decisions) and "public reports" (after feedback on prices). The crucial difference is that, at the stage of the "public" report, subjects know the price chosen by competitors. A deviator would hence report at the "secret" stage in order to become the first leniency applicant. This strengthens the incentives to deviate and report, and makes the leniency scheme more effective. For simplicity, our design nevertheless follows Hinloopen and Soetevent (2008) who implement "public reports" only. Though Bigoni *et al.* (2012) show that having "secret reports" matters a lot empirically in general, there are reasons to believe that the drawback does not matter much in the present study. For our design and numerical parameters, only the deviating firm has an incentive to report (in fact, has a dominant strategy) whereas the cheated-upon firms should not report. In theory, the deviator is the first (and only) leniency applicant (see the Appendix). Hence, not allowing for "secret reports" should theoretically not reduce deviating incentives too much in our case compared to a variant where they are possible. In the experiment, revenge reports by cheated-upon firms are still possible whereas, in Bigoni *et al.* (2012), deviators can prevent these by reporting at the first (the "secret") reporting stage. So the drawback might still matter. We add, though, that even if our design reduces the number of leniency applications for this reason, this would be the case for all our treatments. If so, we would still be in a position to observe treatment differences regarding reporting *certeris paribus*.

2.2 Detailed account of the stages of the experiment

We now explain the stages in turn.

Stage 1. The three firms simultaneously and independently decide whether they want to establish a cartel. They press either the *discuss price* or the *do not discuss price* button on the computer screen. Only if all three firms decide to participate in price discussions a cartel is established, and a communication window opens. Depending on the treatment, firms have access to either structured or free chat communication (see section 2.3).

Stage 2. Firms simultaneously and independently choose an integer price from the set {101, ..., 110}. The lowest price among the three ask prices p_i with $i \in \{1, 2, 3\}$ is the market price, denoted by $\underline{p}$. Only firms that bid $\underline{p}$ are able to sell their product (Bertrand competition). The inelastic demand is normalized to one, so firm i's profit is:

$$\pi_i = \begin{cases} \dfrac{p_i - c}{n} & \text{if } p_i = \underline{p} \\ 0 & \text{if } p_i > \underline{p} \end{cases}$$

where c denotes the marginal cost of production of 100 and $n \in \{1, 2, 3\}$ is the number of firms charging $\underline{p}$. Firms learn $\underline{p}$ and their own profit as feedback afterwards. Profit is the gain resulting from the market interaction, which may subsequently be reduced by penalties and private damage claims.

Stage 3. Firms decide whether to report any existing cartel to the authority and thereby apply for leniency. Reporting costs $r = 1$ point (the experimental currency unit) that represent legal fees for filing a leniency application. There is a "race to report": the first leniency applicant gets a 100% fine reduction and the second applicant gets 50%; the third applicant does not receive a reduction. If no participant reports the cartel, it may still be detected by the authority, namely with a probability of $\rho = 0.15$ in each period. If a cartel is detected (either through a whistleblower or the random draw of the authority), each cartel member has to pay a fine, F, equal to 10% of the current period revenue.[13], [14]

Stage 4. Private damage claims may occur after a cartel is detected. Since we do not include cartel customers in our experiment, this stage is not a decision. Rather, the damage claims are simply enforced with a probability of $\sigma = 0.95$.[15] If the private enforcement case is won in favor of the injured party, the cartel has to compensate 60% of the total damage.[16] The damage inflicted is the difference between the cartel price and the competitive (Nash equilibrium) price, 101 (European Commission, 2014, par. (39)), summed over the number of periods, T, where the cartel formally exists. A cartel is established once all firms in one group decide to communicate by clicking the *discuss price* button. A cartel formally exists as long as it is not reported by a cartel member nor detected by the cartel authority in stage 3. In consequence, the cartel continues to exist even if one or more cartel members deviate from the price agreed upon during the communication phase and do not report. Similarly, a cartel continues to exist even if cartel members communicate only once at the very beginning of the cartel or stop communicating for any number of periods in-between. For each period in which a cartel formally exists, the cartel price is defined as the market price in the given period.

According to the European Commission (2014, par. (37)) cartel members are jointly liable for the total damage, and therefore, each cartel member has to pay one third of the damage compensation. The per-firm per-period damage reads $D_i = \frac{1}{3}(p - 101) \cdot 0.6$ where p is the price

[13] The revenue is defined as the quotient of the market price and the number of firms that sell at market price, see A.1

[14] These fines are consistent with European policy, including the "race to report" (European Commission, 2002, par. (23)b). Leniency applicants are immune or eligible to reductions of fines levied on infringers by the Commission (European Commission, 2006). Those who are first to report are fully relieved from cartel fines; "subsequent companies can receive reductions of up to 50% on the fine that would otherwise be imposed (European Commission, 2011)." In line with European competition law, fines shall not exceed a maximum of 10% of a firm's overall annual turnover when the respective firm is not eligible to reductions of fines (European Commission, 2011). These parameters are also used in Bigoni *et al.* (2012) and Hinloopen and Soetevent (2008).

[15] If damage claims are brought to court, the probability that a case is won is presumably relatively high because one goal of the Directive on antitrust damages actions (European Commission, 2014) is to make it easier for injured parties to get evidence (European Commission, 2015). A large share of private damage claims are also settled out of court (Bourjade *et al.*, 2009).

[16] For two reasons it is reasonable to assume that the total damage is not compensated. First, not all buyers will claim damages, for example, because the buyer structure is fragmented or because it is costly to open a case. Second, it could be the case that part of the damage is passed on in the value chain. The passing-on argument can serve as a strategy of defense of the cartel members against a claim for damages (European Commission, 2014, par. (39)).

the cartel charges in some period and 101 is the counterfactual (Nash) price. For example, fixing the cartel price at 110 (the maximum possible price), the compensation each cartel member has to pay for each period of the cartel's duration is $\frac{1}{3} \cdot (110 - 101) \cdot 0.6 = 1.8$. Table 1 summarizes the calculation for the damages and draws a comparison to fines.[17]

	Fine	Private damage claims
Probability of imposition (if caught)	100%	95%
Basis	Current period firm revenue	Cumulated damage
Magnitude	10% each firm	60% jointly
Possibility to reduce	Yes	No

Table 1: Comparison of fines and private damage claims.

2.3 Treatments

Our main treatment variable is the presence of private damage claims in stage 4. In the treatment labeled NOPDC, they are absent (there is no stage 4). In treatment PDC, they are potentially imposed. We conduct these two treatments *within subjects*: participants first play NOPDC and then PDC.[18]

Periods	1 ... 9	10	11 ... end
Treatment	NOPDC	NOPDC, introduce PDC after stage 2	PDC
Stages	1	1	1
	2	2	2
	3	3	3
		4	4

Table 2: Within-subjects variation of private damages. Participants first play nine periods of NOPDC (stages 1–3). In period 10, the new PDC rule (stage 4) is announced after stage 2. Then, subjects play PDC (stages 1–4) for the remainder of the experiment.

[17] Modeling fines which cumulate over the periods that the cartel exists instead of a linear fine would notably reduce the difference between fines and damages. While in our setting non-deviators do not have an incentive to report the cartel, in a setting with cumulated fines also non-deviators could have an incentive to report the cartel as they would suffer from fines of former periods revenues. Hence, with cumulated fines collusion could become less attractive and stable. Further research could analyze whether cumulated fines have effects similar to private damage claims in PDC+ (see section 5).

[18] This within-subjects design allows us to observe cartels that were set up before the introduction of the PDC rule, such that the introduction of private damage claims comes unexpectedly for existing cartels. Empirically, it turns out there are only few such cases, so we refrain from exploiting this advantage of the experimental design.

Each experimental session consists of at least 20 rounds. From period 20 onwards, the session ends with 20% probability. Such a random termination rule is suitable for avoiding end-game effects (Normann and Wallace, 2012). As table 2 shows, subjects play nine periods of NOPDC. In period 10, the rules of the game change as we introduce private damage claims, after stage 2 (see table 2). From period 11 on, they play PDC for the rest of the experiment. The instructions (see Appendix A.10) mention that the rules might change during the course of the experiment, but they did not indicate when the change would occur nor what it would entail.[19]

In the field, private damage claims were introduced after and in addition to existing public enforcement, justifying the sequence NOPDC-PDC on which we focus in our experiment. For the sake of completeness, the reverse order PDC-NOPDC may seem warranted. We accordingly conduct sessions with the reverse order of treatments. Thereby, we can control for possible order effects by comparing the first 10 periods of each treatment sequence, for example, the first 10 periods of NOPDC–PDC with the first 10 periods of PDC–NOPDC. In the variant form of reverse order, stage 4 is removed (rather than added) in period 10.

As mentioned, we also modify the communication format in two treatments. This treatment variable is analyzed *between subjects*, that is, the treatment of different communication designs is done in separate experimental sessions. Potential carry-over effects (hysteresis) of the different communication formats make a within-subjects design unappealing in this case.

The communication formats are labeled CHAT and STRUC. (The procedure of structured communication (STRUC) closely follows Hinloopen and Soetevent (2008). It resembles experiments where subjects may announce prices non-bindingly but cannot communicate otherwise (Harrington *et al.*, 2016; Holt and Davis, 1990)). Hence, in sessions with STRUC, participants are only able to suggest a price range for which the good could be sold. Specifically, subjects can enter a minimum and a maximum price (within the range of {101, ..., 110}) in the communication window. In subsequent rounds of price discussions (in the same period), subjects can choose prices from the

[19] An alternative setup would have been to repeat the supergames in order to facilitate learning. This, however, would have precluded the within-subjects "before and after" evaluation of private damages which we considered essential for external validity.

intersection of all three suggested price ranges from the preceding discussion. If no intersection exists, subjects can choose a price from the complete price range. This iterative process lasts until either the subjects (non-bindingly) agree on a common price or after 60 seconds have passed (which, according to Hinloopen and Soetevent (2008), is sufficiently long enough.) After the communication phase has ended, subjects get feedback on the agreed upon price or the price interval.

In sessions with CHAT, subjects can freely communicate in a chat window. We allow for open communication, letting subjects exchange any information they want (except for offensive messages, or messages identifying participants). After 60 seconds, the chat window closes and subjects enter stage 2. Among others, Cooper and Kühn (2014), Fonseca and Normann (2012) and Harrington *et al.* (2016) have used similar chat devices in oligopoly experiments. Brosig *et al.* (2003) investigate the issue of the communication format on cooperation in general.

Table 3 summarizes our treatments. It also indicates the number of groups and participants for each treatment. In chapter 5, we introduce and analyze an additional treatment, which is labeled PDC+ and also involves 48 subjects.

Sequence	Communication	Number of indep. groups	Number of participants
NOPDC - PDC	STRUC	16	48
NOPDC - PDC	CHAT	16	48
PDC - NOPDC	STRUC	16	48
$\sum$		48	144

Table 3: Overview of treatments.

2.4 Procedures

The experimental sessions were conducted in the summer and fall of 2018 at the DICE-Lab of Duesseldorf University. We had a total of 192 participants. Subjects were students from all over campus. They had previously indicated their general willingness to participate in lab experiments by registering for our database and were then recruited for this experiment using ORSEE (Greiner, 2015).

Upon arrival at the DICE-Lab, subjects were welcomed and allocated to isolated computer cubicles. We used a randomization device to assign the cubicles. After all participants were seated, they were given written instructions. Subjects were given ample time to read the instructions and they had the opportunity to ask the experimenter questions (in private). Then, the actual experiment began.

During period 10, the experiment was interrupted and a second set of written instructions (which explained the change regarding private damages) was distributed. The change of rules was also announced on the computer screen and comprehension was checked with control questions.

The experiment was programmed using z-Tree software (Fischbacher, 2007). Sessions lasted about one hour on average. Payments were as follows. Participants received an initial capital of 5 euros. Cumulated payoffs were added to or subtracted from the initial capital. The exchange rate was one point equal to 0.3 euros. The average payment was 13.08 euros.

3 Hypotheses

In this section, we will use the following notation (for a comprehensive overview of all variables and their numerical realizations in the experiment, see Appendix A.1). The collusive profit per firm is denoted π_i^c. In the static Nash equilibrium, each firm earns π_i^n. The profit of a defecting firm is denoted π_i^d. Reporting costs are r. Unless reported, a cartel is detected by the authority with a probability ρ and, if so, the authority imposes a fine F_i^j per firm i and outcome $j \in \{c, d, n\}$, with c for collusion, d for deviation and n for Nash. A busted cartel faces damage claims with probability σ. The per-firm per-period damage is denoted by D_i^j. Damages are cumulated over the time of cartel duration. Fines and damages depend on the price and thus differ in periods of collusion and defection.

We assume that the market game is repeated infinitely many times and that firms discount future profits with a discount factor δ.[20] A further assumption is that firms collude on the maximum price (110) and use a simple Nash trigger to support collusion, such that the static

[20] In the experiment, a stopping probability (which corresponds to discounting) is effective only after 20 periods. One can show (proof available upon request) that this changes incentives only qualitatively and to a minor extent.

Nash profit, π^n, is the punishment profit after a deviation.[21] For simplicity and following Bigoni *et al.* (2015), we assume that firms communicate once to establish successful collusion and collude tacitly after a detection by the authority. That is, firms risk being fined only once.[22] Formal proofs of the statements in this section can also be found in Appendix A.1.

Our first hypothesis is about cartel formation, that is, the number of newly formed cartels. The economic theory of crime predicts that criminal activity decreases in the expected costs of the activity (Becker, 1968). We derive this formally (see Appendix A.1 for details) from the cartel's *participation constraint* which must necessarily be met, see also Bigoni *et al.* (2015) or Chowdhury and Wandschneider (2018). The expected discounted profit from colluding minus the expected fine (left-hand side of the equation) must be at least as high as the expected discounted profit from competing à la Nash (right-hand side of the equation). For the NOPDC case, we have

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) \quad \geq \quad \frac{\pi_i^n}{1-\delta}$$

where $E(F_i^c)$ is the expected discounted fine. Private damage claims increase the expected costs of cartel formation because firms now need to cover the expected damages in addition to the fines. For PDC, the cartel participation constraint reads

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) - E(D_i^c) \quad \geq \quad \frac{\pi_i^n}{1-\delta}$$

where $E(D_i^c)$ is the expected, discounted, and cumulated, per-firm damage payment resulting from successful collusion. The total damage (D^c) is equally split between all three cartel members such that $E(D_i^c) = E(D^c/3)$. For our experimental parameters, both participation constraints are met, but, with private damages, the cartel participation constraint is more severe. We thus

[21] Colluding on the maximum price seems plausible as this maximizes joint profits. It is possible, however, to lower the threshold discount factor by choosing a lower collusive price. Since this effect is of minor magnitude and similar in all treatments (and hence does not affect our hypotheses), we refrain from exploring this issue in detail. We further note that punishments more severe than Nash are not feasible here because the Nash price is also the lowest price firms may charge.

[22] Alternatively, we could assume that busted cartels never resume the collusion but play Nash after a detection. However, with our experimental parameters the return to Nash assumption reduces profits too strongly, such that collusion is not rational for some treatments.

maintain:

Hypothesis 1 ***(Cartel formation)*** *Private damage claims reduce the number of cartels.*

The next hypothesis concerns the reporting behavior of firms: In which treatment – PDC or NOPDC – will firms apply for leniency more often? Firms only have an incentive to report a cartel when they deviate from the cartel price (reporting and not deviating is not beneficial because the cartel will cease to exist after the report anyhow). Deviations, in turn, can occur with unexpected trembles in the discount factor (Buccirossi *et al.*, 2015).[23] Given a firm deviates, it is rational for this firm to report in all treatments (this keeps treatments comparable), but a comparison of the costs of reporting across treatments shows the following insights. In treatment NOPDC, reporting only involves r, the immediate cost of reporting. In treatment PDC, firms also incur r but they additionally need to pay damages σD_i^d. For the experimental parameters, it turns out that reporting costs for the deviator are more than 2.5 times higher under PDC than under NOPDC (Appendix A.1). Thus, the costs of reporting increase and the incentive to apply for leniency strongly decreases with private damages. Assuming that firms occasionally make mistakes but make costly mistakes less often than cheaper ones, we hypothesize:

Hypothesis 2 ***(Leniency)*** *Private damage claims reduce the frequency of leniency applications.*

We now analyze the dynamic incentives to collude. As mentioned, firms attempt to maximize joint profits with a trigger strategy involving Nash reversion. Cartel firms remain liable for the agreement in future periods, until detected or reported. The incentive constraints required for collusion to be a subgame perfect Nash equilibrium read as follows. Without private damages (NOPDC), sticking to the collusive agreement is (weakly) better than defecting if

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) \quad \geq \quad \pi_i^d - r + \frac{\delta \pi_i^n}{1-\delta}.$$

[23] Other motives for deviations may occur when firms trade off the risk of a collusive equilibrium against a less risky defect strategy (Buccirossi *et al.*, 2020; Green *et al.*, 2015). Similarly, US Horizontal Merger Guidelines acknowledge the role of disruptive maverick firms (Darai *et al.*, 2019; Kovacic *et al.*, 2007), and such mavericks may have an incentive to deviate, for example, due to a merger motive.

With private damages (PDC), colluding is better than defecting if

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) - E(D_i^c) \quad \geq \quad \pi_i^d - r - \sigma D_i^d + \frac{\delta \pi_i^n}{1-\delta}$$

where we note that damages have to be paid in either case, but they differ in magnitude (see Appendix A.1 for details). Again, the total damage (D^j) is equally shared among all cartel members, which implies $E(D_i^j) = E(D^j/3)$. Let the minimum δ that solves the NOPDC and PDC incentive constraints be δ_{min}^{NOPDC} and δ_{min}^{PDC}, respectively. We find that

$$\delta_{min}^{PDC} < \delta_{min}^{NOPDC}.$$

For the parameters in the experiment, we obtain $\delta_{min}^{NOPDC} = 0.664$ and $\delta_{min}^{PDC} = 0.655$. With a continuation probability of 0.8, both incentive constraints are met in the experiment and so collusion is an SGPNE in either case. We follow the frequently adopted interpretation that a lower minimum discount factor suggests that collusion is more stable, provided a cartel is actually set up. Hence, we state:

Hypothesis 3 ***(Cartel stability)*** *Existing cartels are more stable when private damage claims are possible.*

An interesting observation is that reporting costs and the incentive constraint under private damages become more severe over time because damages are cumulated. Deviations become more and more costly in later periods. Private damages accordingly have a self-enforcing effect on collusion. In theory, this effect is immaterial, though. All that matters is whether the incentive constraint is met in period zero when the incentive to deviate is at its maximum. The fact that the bill for reporting gets higher and higher could be important, though. For example, unanticipated shocks to collusion may be absorbed only with the high exit cost that the cumulated damages imply.

Our hypotheses suggest an overall ambiguous effect of private damage claims. On the one hand, there should be fewer cartels. On the other hand, cartels should be more stable and there may be less reporting in PDC. The overall balance in terms of cartel prevalence is ex ante not clear and we do not maintain a directed hypothesis here.

Statement 4 (Cartel prevalence) *The overall effect of private damage claims on cartel prevalence is ambiguous.*

As with cartel prevalence, we do not maintain a directed hypothesis about market prices (the measure for consumer welfare). Market prices (the lowest of the three ask prices) are affected by (at least) two channels. First, market prices may decrease because, according to hypothesis 1, fewer cartels are formed with private enforcement, leading to more competitive prices. Second, any existing cartels would suffer less from leniency (hypothesis 2) and may be more stable (hypothesis 3) and should therefore have higher market prices, on average. The overall effect is ambiguous. Of course, we can look at the effect of PDC for cartelized markets only. But, even here, the effect is ex-ante ambiguous. On the one hand, cartels under PDC may collude more successfully due to a selection effect (only rather collusive-minded firms form a cartel despite the more severe constraints). On the other hand, cartel members could fear damage claims and therefore lower the prices.

Statement 5 (Market prices) *The overall effect of private damage claims on market prices is ambiguous.*

Our final hypothesis is about the impact of the different forms of communication. Existing experimental evidence (Cooper and Kühn, 2014; Fonseca and Normann, 2012) suggests cartels are more stable when subjects can communicate. It appears that open communication fosters trust between players (Brosig *et al.*, 2003). Also, subjects can communicate entire strategies rather than just price targets. Furthermore, chat communication can enhance the understanding of the mutual benefits of collusion in their group. Kruse and Schenk (2000) observe that only one group member has to understand the profit-maximizing strategy and can use the chat to convince its group members to comply.

Hypothesis 6 ***(Impact of communication)*** *Compared to structured communication, unrestricted communication increases cartel formation and stability.*

4 Results

To analyze the impact of private damage claims, we foremost analyze the data within subjects. That is, we compare the first 10 periods (NOPDC) to the subsequent 10 periods (PDC). We restrict the analysis to observations from periods 1 to 20 in order to exclude potential end-game effects. With the help of the reverse-order control treatment, we then compare the data between subjects to exclude possible order effects (both PDC and NOPDC data from periods 1 to 10). We use non-parametric tests like the Wilcoxon matched-pairs test (WMP) for the within-subjects analysis and the Mann-Whitney U test (MWU) for the between-subjects analysis. With the WMP-Test, we match the NOPDC with the PDC observations of each group. For all analyses, we first take the average per group as one observation and aggregate across groups afterward. In total, we have 16+16 observations. When we analyze the share of firms that report a cartel, we generally have fewer observations because the analysis is conditional on having a cartel in the first place, which is not the case for all groups.

We complement the non-parametric tests with linear regression models (ordinary least squares) with and without time fixed effects. We run the estimations separately for each communication treatment. Due to the fixed group structure, we cluster standard errors at the group level. We bootstrap the standard errors with 1,000 replications. Statistical significance levels are indicated by an asterisk, where $^{+}$ $(p < 0.15)$, * $(p < 0.1)$, ** $(p < 0.05)$, *** $(p < 0.01)$. We report two-sided p-values throughout.

An overview of the summary statistics of our main results is displayed in table 4. The precise definition of each variable can be found in table 12 in Appendix A.2. The exact values underlying figures 2 to 9 can be obtained from table 4.[24]

[24] For the exact values of PDC taken from the sequence PDC-NOPDC in figures 4, 7, 9 see table 17. Refer to table 4 for the exact values of NOPDC for the sequence NOPDC-PDC.

	STRUC		CHAT	
	NOPDC	PDC	NOPDC	PDC
Propensity to collude	0.619 (0.142)	0.394 (0.192)	0.578 (0.288)	0.225 (0.289)
Share cartel	0.207 (0.153)	0.019 (0.054)	0.271 (0.373)	0.063 (0.250)
Share report	0.462 (0.230)	0.296 (0.339)	0.103 (0.214)	0.000 (0.000)
Cartel stability	1.000 (0.000)	2.167 (0.866)	6.556 (3.522)	8.000 (1.441)
Cartel prevalence	0.238 (0.178)	0.063 (0.163)	0.325 (0.380)	0.163 (0.359)
Market price	102.706 (2.009)	101.681 (2.095)	105.913 (3.969)	107.038 (4.227)

Table 4: Summary statistics of the results in the treatments NOPDC–PDC (STRUC and CHAT); average results per treatment (standard deviations in parentheses).

4.1 Cartel formation

Hypothesis 1 states that cartel formation decreases when private damage claims are introduced. Consider the individual level first: how often do subjects press the *discuss price* button when they are not already in a cartel? (For this and all other variable definitions, consult table 12 in the appendix.) Without private damages, the average propensity to collude in STRUC (CHAT) is 61.9% (57.8%), see figure 2 and table 4. With PDC, the average propensity to collude decreases to 39.4% (22.5%), and the reduction is significant (STRUC: WMP, $p\text{-}value = 0.0007$; CHAT: WMP, $p\text{-}value = 0.0015$). For both communication treatments, the individual propensity to form a cartel declines by about 35–22 percentage points when PDC are possible. The estimation results of the linear probability model in table 5 are also consistent with hypothesis 1. We see that the dummy variable PDC is highly significant and economically substantial.

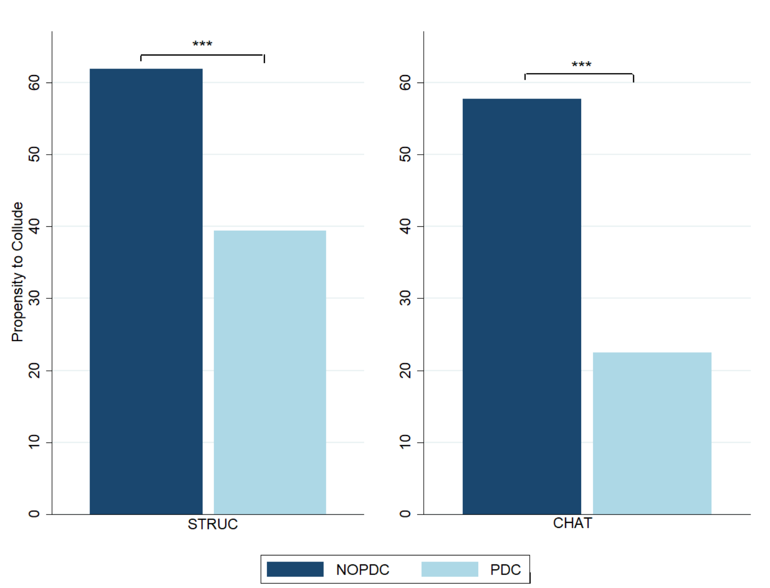


Figure 2: The impact of PDC on the individual propensity to collude in STRUC (left) and CHAT.

	(1) Collude	(2) Collude	(3) Collude	(4) Collude	(5) Collude
PDC	-0.225***	-0.219***	-0.208***	-0.604***	-0.0925***
	(0.0353)	(0.0482)	(0.0497)	(0.0926)	(0.0317)
constant	0.592***	0.381***	0.583***	0.729***	0.550***
	(0.0350)	(0.0605)	(0.0537)	(0.0648)	(0.0524)
Time FE	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	960	960	960	960	1,860
R^2	0.051	0.060	0.063	0.106	0.033

Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Individual decisions to communicate – linear regression (standard errors in parentheses).

Next, consider the market (or group) level. Here, we ask the question, how often is a cartel actually established? This is the case when all three group members press the *discuss price* button, given they are not already in a cartel. Figure 3 and table 4 show the results. We observe that, with PDC, the share of newly formed cartels is strongly and significantly reduced (STRUC: WMP, *p-value* $= 0.0007$; CHAT: WMP, *p-value* $= 0.0087$). As above, this holds for both communication treatments, STRUC and CHAT. The regressions in table 6 confirm that the effect is significant.

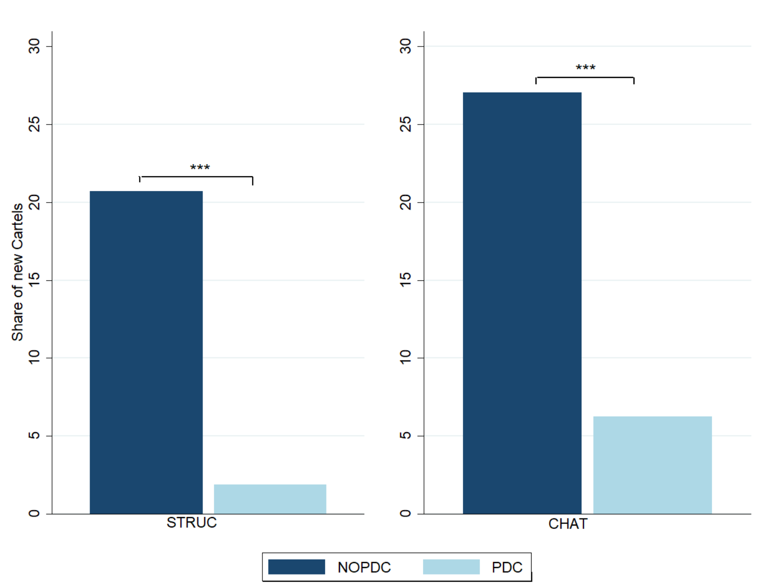


Figure 3: The impact of PDC on the number of cartels in STRUC (left) and CHAT.

	(1) Collusion	(2) Collusion	(3) Collusion	(4) Collusion	(5) Collusion
PDC	-0.181***	-0.0813***	-0.125+	-0.375***	-0.0773***
	(0.0311)	(0.0130)	(0.0817)	(0.116)	(0.0244)
constant	0.194***	0.0875***	0.125+	0.375***	0.166***
	(0.0344)	(0.0172)	(0.0817)	(0.116)	(0.0628)
Time FE	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	320	320	320	320	620
R^2	0.089	0.037	0.119	0.183	0.069

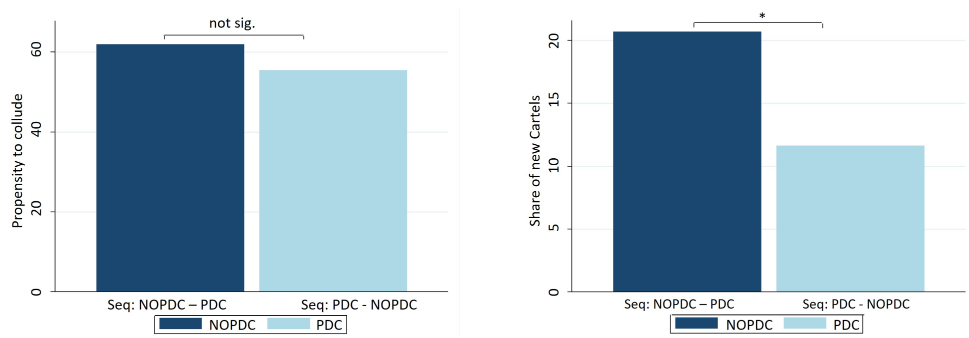
Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Group decisions to communicate – linear regression (standard errors in parentheses).

Exploiting the treatment with the reverse sequence PDC-NOPDC with structured communication, we compare the first 10 periods of the NOPDC-PDC sequence with the first 10 periods of PDC-NOPDC sequence. This allows us to additionally conduct the comparison NOPDC and PDC between subjects, thereby excluding order effects.[25] Figure 4 shows that the possibility of PDC reduces cartel formation in STRUC both at the individual (a) and at the group (b) level. The reduction is statistically significant at the market level ((a) MWU, *p-value* $= 0.153$ (b) MWU,

[25] Due to bankruptcy we exclude one group in the reverse-order treatment from our analysis.

p-$value = 0.0899$).[26] For the sake of completeness, results of the PDC-NOPDC session analyzed within subjects can be found in Appendix A.7. We also control for possible order effects by analyzing whether our main variables of interest are significantly different under each treatment, when the treatment is run in periods 1–10 rather than 1–20. We do so by conducting MWU-tests (see Appendix A.8), as well as a pooled data analysis from the main structured treatment and the reverse-order treatment (see table 5-10 column (5)). These results suggest that there are no order effects. However, the pooled data analysis yields slightly smaller effects. One possible explanation might be that the introduction of private damages would reduce cartelization, but the effect would be amplified by the regime shift and would become smaller in the long run.



(a) Propensity to collude

(b) Share of cartelized markets

Figure 4: Cartel formation in STRUC: between-subjects comparison with PDC data from treatment with reverse order (PDC-NOPDC).

Result 1 (Cartel formation) With PDC, there are significantly fewer attempts to form a cartel (individual level) and significantly fewer successfully formed cartels (group level).

4.2 Leniency applications and cartel stability

Hypotheses 2 and 3 are about leniency behavior and cartel stability. For these analyses cartels need to have actually been formed in the first place. We compare the first nine periods NOPDC and period 11 to 19 PDC.[27]

[26] Linear regressions, available upon request, yield the same result.

[27] For the analyses of leniency applications and cartel stability, we exclude period 10 (for reasons of symmetry also period 20). Subjects decide whether to report a cartel after private damage claims are introduced. Thus, period 10 belongs to neither PDC nor NOPDC. For the analysis of variables other than stability this problem does not exist because decisions about cartel formation or price setting were made before the introduction of private damage claims.

Leniency applications

Hypothesis 2 suggests that there will be fewer leniency applications with PDC. We first analyze the share of individual reporting decisions by each group, that is, we consider the sum of subjects in each group revealing the cartel over all periods that any cartel exists (see table 12 for the definition of *share report*).

Figure 5 and table 4 show that PDC significantly decreases the share of leniency applications in each group in STRUC (STRUC: WMP, *p-value* $= 0.101$; CHAT: WMP, *p-value* $= 0.3173$). In the case of STRUC, the effect is also economically substantial.

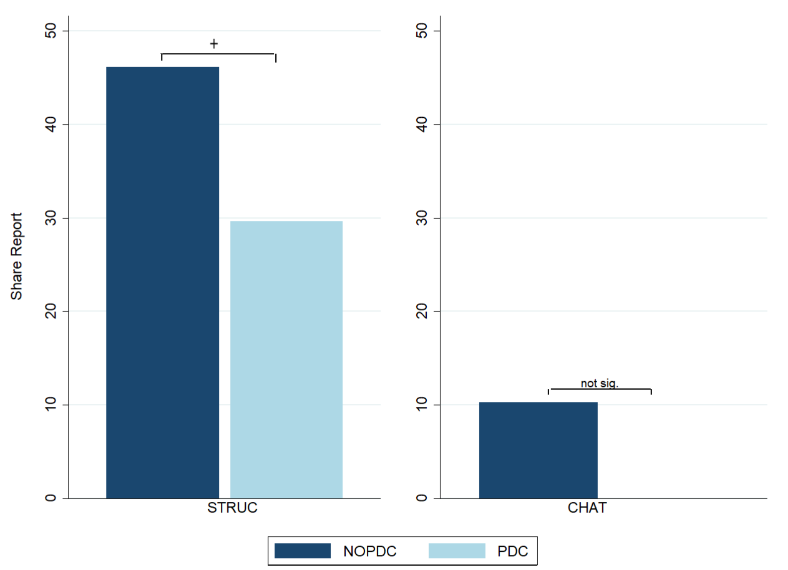


Figure 5: The impact of PDC on the individual reporting decision in STRUC (left) and CHAT.

Table 7 reports a linear regression of PDC on the individual decision to report a cartel. In STRUC as well as in CHAT the number of cartel members applying for leniency decreases when PDC occur. However, this effect is only significant in the STRUC regressions without time fixed effects. The between-subjects comparison indicates that the share of leniency applications does not differ between NOPDC and PDC. Our interpretation is that subjects may have had too little time – only one repetition of the supergame – to learn the impact of private damages and are thus not more disinclined to report than in NOPDC.

	(1) Report	(2) Report	(3) Report	(4) Report	(5) Report
PDC	-0.264^{+}	-0.0347	-0.167	-0.0556	-0.0400
	(0.178)	(0.0250)	(0.128)	(0.0494)	(0.0839)
constant	0.412***	0.0347	0.167	0.0556	0.270
	(0.0674)	(0.0250)	(0.128)	(0.0494)	(0.165)
Time FE [Period 1-19, without 10]	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	129	216	129	216	252
R^2	0.050	0.012	0.138	0.077	0.114

Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Individual decision to report a cartel – linear regression (standard errors in parentheses).

Result 2 (Leniency rate) Compared to NOPDC, there are fewer leniency applications with PDC.

Cartel stability

Hypothesis 3 is that cartels become more stable as we introduce private damage claims. In order to analyze cartel stability, we compare the mean number of periods when a cartel was stable,[28] in NOPDC and PDC, conditional on cartel existence. Cartels that are formed and uncovered in the same period count as stable for one period (see also table 12.) Descriptive results show that the mean of cartel stability roughly doubles in STRUC (in NOPDC 1.0 stable period compared to 2.2 in PDC). In CHAT, stable periods increase from 6.6 in NOPDC to 8.0 in PDC (see table 4). Whereas this result is in line with hypothesis 3, we cannot make any statement about significance because there are too few groups forming a cartel in NOPDC and PDC. For the same reason, we cannot conduct survival estimates.

Result 3 (Cartel stability) With PDC, cartels are more stable.

In connection with hypothesis 3, we noted that private damages have an enforcing effect on stability over time because damages cumulate. Cartels should, accordingly, be more strongly discouraged from reporting the longer they exist.

[28] A cartel is stable until it is reported or detected by the authority. Of course, cartels may continue to set a high price after being reported or detected. For such pricing behavior, they cannot be penalized.

4.3 Cartel prevalence

We finally look at cartel prevalence, defined as the percentage of periods where a stable cartel existed. Result 1 on the one hand, and results 2 and 3 on the other, suggest an overall ambiguous effect of PDC on cartel prevalence: fewer cartels are formed but these remaining cartels are more stable. (Due to this ex-ante ambiguity, statement 5 in section 3 is not a directed hypothesis about prevalence.) What is the overall balance?

Figure 6 and table 4 show the results. For the communication treatment STRUC, we find cartel prevalence present in 23.8% (NOPDC) and 6.3% (PDC) of all groups over all periods. In CHAT, we see 32.5% (NOPDC) and 16.3% (PDC) of periods where a stable cartel existed. That is, there is a strong and significant reduction in cartels due to PDC in both communication treatments (STRUC: $p\text{-}value = 0.0051$ and CHAT: WMP, $p\text{-}value = 0.0139$). The linear regressions in table 8 confirm this.

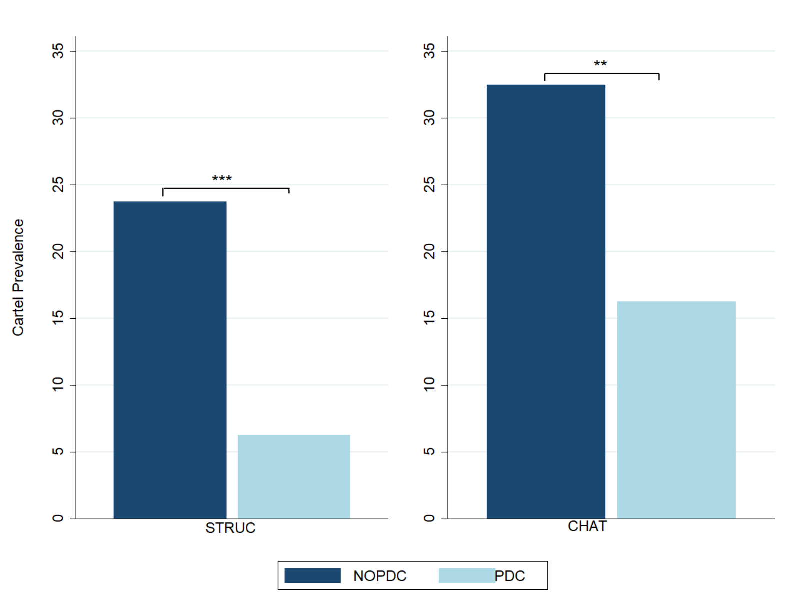


Figure 6: The impact of PDC on cartel prevalence in STRUC (left) and CHAT.

	(1) Prevalence	(2) Prevalence	(3) Prevalence	(4) Prevalence	(5) Prevalence
PDC	-0.175***	-0.163**	-0.0625	-0.250**	-0.111**
	(0.0484)	(0.0797)	(0.106)	(0.105)	(0.0461)
constant	0.237***	0.325***	0.125+	0.375***	0.183***
	(0.0413)	(0.0915)	(0.0817)	(0.116)	(0.0653)
Time FE	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	320	320	320	320	620
R^2	0.060	0.036	0.096	0.061	0.056

Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Cartel prevalence – linear regression (standard errors in parentheses).

We again analyze the treatment with the reverse order, PDC-NOPDC and compare the first 10 periods in NOPDC to those in PDC. The results are similar: the between-subjects test is significant (MWU, $p\text{-}value = 0.0842$).

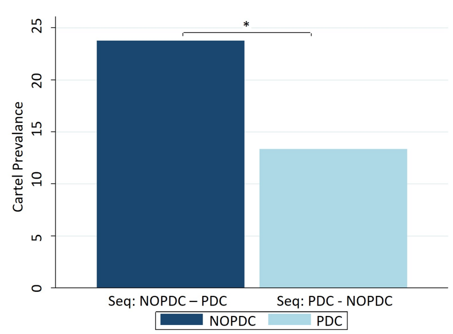


Figure 7: Cartel prevalence in STRUC: between-subjects comparison with PDC data from treatment with reverse order (PDC-NOPDC).

Result 4 (Cartel prevalence) There are significantly fewer cartelized periods with PDC.

4.4 Prices and Consumer Welfare

To complete the analysis of cartel behavior, we examine the market price. This is the lowest price of the three individually entered prices in stage 2.[29] The market price is the relevant factor for consumer welfare (see statement 5 in section 3).

[29] For an analysis of individual ask prices see Appendix A.5.

	STRUC		CHAT	
	NOPDC	PDC	NOPDC	PDC
Market price non-cartels	102.049 (1.897)	101.589 (2.089)	104.566 (3.807)	106.621 (4.373)
Market price cartels	104.654 (2.570)	103.278 (1.669)	109.250 (2.050)	109.967 (0.058)
Market price all markets	102.706 (2.009)	101.681 (2.095)	105.913 (3.969)	107.038 (4.227)

Table 9: Market price – averages per treatment (standard deviations in parenthesis).
Seq: NOPDC–PDC.

We compare the average market price with and without private damage claims across the CHAT and STRUC treatments as shown in table 9 and figure 8. We see that PDC reduce prices in STRUC, but CHAT shows the opposite pattern. This concerns the overall average ("all markets") as well as the market prices of cartelized and non-cartelized markets. The differences are statistically significant in STRUC (STRUC: WMP, *p-value* = 0.0034; CHAT: WMP, *p-value* = 0.2513). In order to control for possible order effects, we conduct the between-subjects comparison based on PDC data from the treatment with the reversed order PDC-NOPDC. Figure 9 verifies the lower overall market prices in PDC with STRUC communication (WMU, *p-value* = 0.0511).

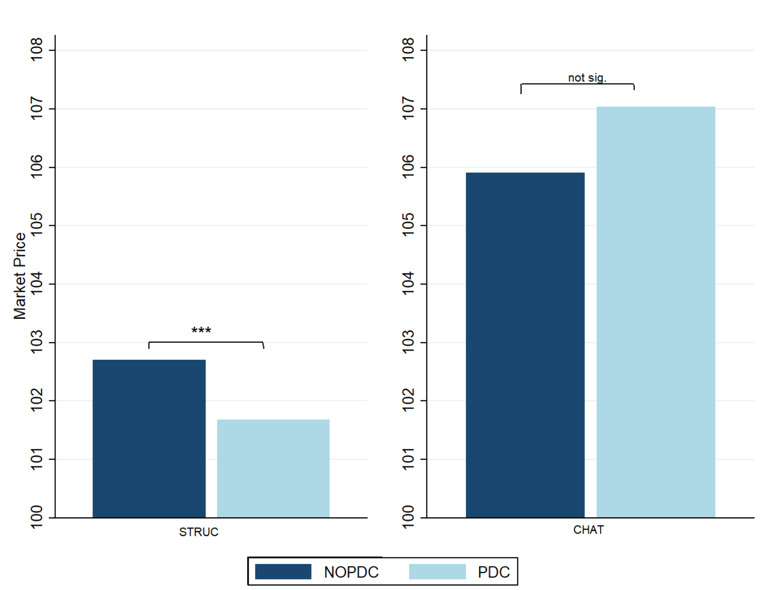


Figure 8: The impact of PDC on market prices in STRUC and CHAT.

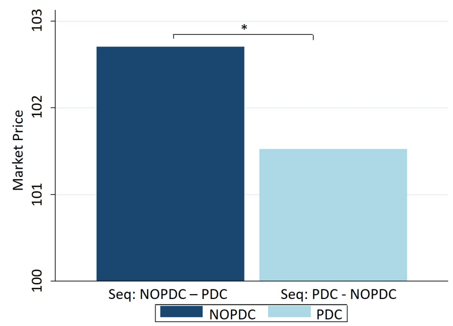


Figure 9: Market price in STRUC: between-subjects comparison with PDC data from the treatment with reverse order (PDC-NOPDC).

Table 10 reports the results from a regression analysis on the dependent variable *MarketPrice*. The results confirm previous observations that market prices significantly decrease in the subsample of STRUC if private damage claims are introduced (table 10, column 1). They significantly increase in CHAT.

	(1) MarketPrice	(2) MarketPrice	(3) MarketPrice	(4) MarketPrice	(5) MarketPrice
PDC	-1.025***	1.125*	-1.563***	1.750+	-0.349**
	(0.256)	(0.588)	(0.468)	(1.174)	(0.150)
constant	102.7***	105.9***	102.8***	104.5***	102.5***
	(0.482)	(0.957)	(0.415)	(0.981)	(0.294)
Time FE	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	320	320	320	320	620
R^2	0.044	0.017	0.060	0.031	0.055

Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^+ p < 0.15$, $^* p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$

Table 10: Market price – linear regression (standard errors in parentheses).

Result 5 (Market prices) With STRUC communication, PDC significantly decrease average market prices and therefore increase consumer surplus. With CHAT communication, PDC increase market prices and therefore decrease consumer surplus.

What could be the intuition for the contradicting effects in CHAT and STRUC? Recall that statement 5 in section 3 is not a directed hypothesis in the first place. Prices could be lower when private damage claims apply because there are fewer cartels and remaining cartels might be reluctant to set higher prices because of the risk of paying damage claims. This is what might be going on in STRUC. In CHAT, subjects have the chance to coordinate their behavior even beyond a cartel breakdown. We suggest that the price effects in CHAT are triggered by a hysteresis effect, that is, prices that stick to the collusive level even after someone busts the cartel (per definition). For a detailed discussion of the price effects please refer to Appendix A.3 and A.4.

Result 5 raises the question of how much weight should be given to the two opposing results. Given that communication is often open and in person in real-world cartels, it appears that the second part on the effects with CHAT should be given more emphasis, suggesting that damage claims in this form lower consumer welfare.[30]

4.5 Structured vs. chat communication

Our experimental design enables us to analyze not only the effect of private damage claims but also the impact of different types of communication designs on cartel formation and stability. As expected from hypothesis 6, we see quadrupled stability in CHAT compared to STRUC across both treatments, NOPDC and PDC (see table 4). This is also emphasized by the result that infringers apply less often for leniency ($p\text{-}value = 0.0011$) (see figure 5). These results are in line with the literature observing that CHAT communication helps to better coordinate (for example, Fonseca and Normann, 2012; Fonseca *et al.*, 2018), or generally, that communication facilitates collusion (see e.g., Bigoni *et al.*, 2019; Cooper *et al.*, 1992; Cooper and Kühn, 2014; Waichman *et al.*, 2014).

Perhaps surprisingly, the propensity to collude—new attempts to collude at the subject level—is significantly higher in STRUC compared to CHAT ($p\text{-}value = 0.0150$) (see figure 2). There are two explanations for this seemingly counterintuitive result. First, CHAT communication facilitates trust among group members and makes group members stick to the agreements more often and, as seen above, report the cartel less frequently. As a result, subjects in CHAT need to press the *discuss price* button less often. Secondly, the lower fraction of subjects deciding in favor of a new price discussion in CHAT is explained by agreements to stick to the collusive price after cartel breakdown. Subjects in CHAT are able to agree on setting the same price as under collusion after

[30] On hysteresis see also Harrington (2004).

they have been detected and without renewing their price discussion. This is not possible in the STRUC design. This can be seen from the following excerpts of communication (translated from the original German), groups agree to communicate only once:

- `Without in future rounds without [sic] communication then?` (group 5, period 1)
- `Yes but not more communication in the next rounds` (firm 3)

  `Ok, no more communication and 110` (firm 2)

  `Alright. Yes. Always 110, no more communication and no reports.` (firm 1, group 13, period 1).

Market prices are higher in CHAT compared to STRUC across all types of markets (*p-value* : 0.0218) (see table 9). As already mentioned, higher prices in CHAT can be explained by an hysteresis effect that keeps prices high even after a cartel breaks down. In line with that, we see much less variation in collusive market prices in CHAT compared to STRUC (*p-value* : 0.0001) (see table 9).

To conclude, CHAT allows subjects to better coordinate their practice compared to STRUC, which leads to an increased stability and hysteresis of cartel prices.

Result 6 (CHAT vs. STRUC) Cartel stability is higher and there are significantly fewer leniency reports in CHAT. The propensity to collude is significantly lower in CHAT.

5 Protection from damages for the leniency applicant

Although in an overall assessment of PDC we find a decreasing cartel prevalence in PDC, the results of the preceding section 4 also suggest that private damage claims may lower leniency application rates so that cartels are more stable. This negative effect of PDC on leniency and cartel stability suggests a careful reconsideration of the tool of private enforcement.

Better protection of whistleblowers is an obvious option. Kersting (2014) proposes an approach in which the leniency applicant can obtain full compensation for damage payments from its co-infringers. Similarly, Kirst and van den Bergh (2016) suggest a reduction of damage payments of leniency applicants corresponding to the reduction in fines. This should remove the tension between private and public enforcement. As formally demonstrated by Buccirossi *et al.* (2020), damage claim actions and leniency programs can reinforce each other when the first leniency applicant's liability is minimized (or even eliminated) also with respect to damage claims. This scheme corresponds to the former Hungarian legislation before the implementation of the directive on antitrust damage actions (Buccirossi *et al.* (2020); European Commission (2014)). In a related piece of experimental evidence, Mechtenberg *et al.* (2020) analyze whistleblowing in the context of corporate fraud. They find that an increase in reports can be triggered by better whistleblower protection.

In order to test such a potential improvement of the current European legislation, we introduce a new treatment called PDC+. In this new treatment, the first leniency applicant is fully protected from private damage payments. The remaining two cartel firms jointly pay the damage payment (which remains at 60% of excess Nash industry profit). That is, the remaining cartel members, no matter whether they also reported the cartel, have to pay half of the per-period damage compensation, $D_i^j = \frac{1}{2}(p_i^j - 101) \cdot 0.6 = D^j/2$. By contrast, in our standard PDC treatment, all three cartel members pay one third of the damage ($D^j/3$). Private damage claim actions in PDC+ are enforced with a probability of $\sigma = 0.95$ and they are cumulated over time, as in PDC. If no reporting takes place the cartel authority detects the cartel by probability $\rho = 0.15$, the design follows the PDC treatment as explained in section 2.

We study one of several possible designs to analyze the effect of the benefit of the leniency applicant. As in the main treatment, we conduct the experiment also on the basis of a within-subjects comparison. Thus, the treatment order is PDC-PDC+ and we use the STRUC communication treatment. Participants first play nine periods with private damages as above, followed by PDC+ in the remaining periods. Again, the rules of the experiment change in period 10 and PDC+ is introduced after stage 2 (price decision). The extension of the experiment was conducted in the structured communication setting and was programmed using z-Tree software (Fischbacher, 2007). The sessions took place in January and July 2020 and involved 48 participants.

What are our hypotheses for PDC+? First, the participation constraints in PDC+ and PDC are the same because fines and damages for successful collusion do not change compared to PDC (only deviation and reporting change). We thus do not expect an impact on the frequency of cartels. The costs of reporting are much lower in PDC+ in the case of a deviation, as the deviator will report (which costs r) but pays no fine and no damages (because of the damage-leniency of PDC+).[31] Second, the incentive constraint in PDC+ changes compared to PDC because damages have to be paid only in the case of stable collusion. The incentive constraint thus becomes

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) - E\left(\frac{D^c}{3}\right) \quad \geq \quad \pi_i^d - r + \frac{\delta \pi_i^n}{1-\delta},$$

which is more severe than the constraint obtained above for PDC, so $\delta_{min}^{PDC+} > \delta_{min}^{PDC}$. For the parameters in the experiment, we obtain $\delta_{min}^{PDC+} = 0.682$ whereas $\delta_{min}^{PDC} = 0.655$. That is, PDC+ hinders collusion as intended by the new policy. For all statements, see Appendix A.1 for details.

Hypothesis 7 ***(Protection from damages for the first leniency applicant)*** *More cartels will be reported in PDC+ than in PDC.*

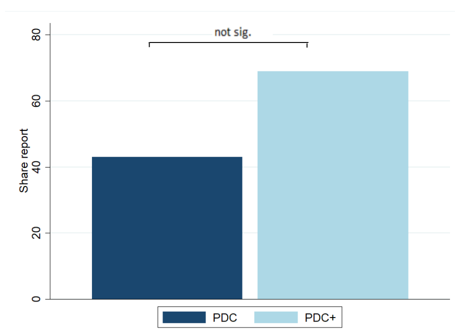


Figure 10: Share report in STRUC: within-subjects comparison from the treatment PDC-PDC+.

The results support the notion that PDC+ results in lower cartel stability. Cartels break down more often due to a higher share of reports by individuals. The within-subjects design results based on group level can be seen in figure 10. We see a reporting share of 43% in the PDC

[31] In the PDC+ treatment, the deviator strategically sets a lower deviation price than in the NOPDC and PDC treatment. The lower price prevents rival firms from reporting (after observing the deviation) and thus maximizes deviation profits. Please refer to Appendix A.1 for detailed explanations.

treatment and a reporting share of 68.9% in the PDC+ treatment, resulting in an increase of 25.9 percentage points. The same holds for the number of stable cartel periods. In the PDC+ treatment, cartels are, on average, 0.33 periods less stable compared to the PDC treatment. Whereas this result is in line with hypothesis 1 for the PDC treatment, we cannot make any statement about significance because there are too few groups forming a cartel in PDC and PDC+.[32]

Results also hold in a between-subjects analysis. In the PDC treatment, we observe a reporting share of 29.6% and 68.9% in the PDC+ treatment, which is significantly higher in PDC+ (see figure 11) ($p\text{-}value = 0.0929$).[33] Linear regressions in table 15 and table 16 in the appendix also show that PDC+ significantly increases the share of leniency applications (see A.6 in the appendix).

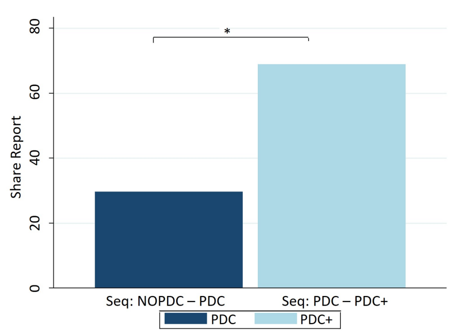


Figure 11: Share report in STRUC: between-subjects comparison with PDC data from NOPDC-PDC and PDC+ data from PDC-PDC+.

Result 7 (Protection from damages for the first leniency applicant) Compared to PDC, there are more leniency applications in PDC+.

6 Conclusion

Private damage claims, introduced into European law through Directive 2014/104/EU (European Commission, 2014), are controversially discussed. This is especially the case when it comes to the adverse effects private damages may inflict on the well-established and successful tool of

[32] An overview of the summary statistics of our other variables can be found in section A.9.

[33] In order to exclude any possible 'Corona Pandemic effects', we conduct a robustness check which can be found in the appendix in table 21.

leniency. Leniency applicants fines are waived or reduced, but their damage claim payments are not reduced, at least not completely, or they are capped only to a certain degree. Private enforcement may therefore decrease incentives to apply for leniency and may result in more stable cartels.

Our work contributes to the literature in two ways. The main goal of our paper is to provide a first quantification of the trade-off between leniency and private damage claims based on the current EU legislation in an experiment. Our design builds on the literature on leniency experiments (Apesteguia *et al.*, 2007; Bigoni *et al.*, 2012; Dijkstra *et al.*, 2020; Hinloopen and Soetevent, 2008). We analyze a repeated cartel game where firms can discuss prices and may later apply for leniency. We extend the literature by allowing for private damages when a cartel is uncovered. Our second contribution is that we vary the form of communication by analyzing structured price announcements vs. unrestricted chat.

The results are as follows. First, we show that the propensity for cartel formation decreases as private enforcement is introduced. Second, when private damage claims exist, subjects tend to apply for leniency less often. Third, the implementation of damage claims has a stabilizing effect on cartels. Fourth, overall there are fewer stable cartels with private damage claims. Fifth, we find ambiguous results regarding consumer surplus depending on the type of communication. Private enforcement decreases prices in a structured communication treatment yielding a rise in consumer surplus, whereas prices seem to increase when subjects are not restricted in communication, implying a decrease in consumer welfare. Sixth, chat-type communication not only lowers the incentives for leniency applications, it also increases cartel stability. Our take on the new instrument is mixed. Overall, cartel prevalence is lower with private damages, suggesting a beneficial impact. However, private damage claims seem to negatively affect leniency application rates and cartel stability.

The ambiguous results suggest a careful reconsideration of the tool of private enforcement. Buccirossi *et al.* (2020) suggest that improved protection from damages for whistleblowers may avoid the negative impact private damages have on leniency.[34] In an extension of our main treatments we show that, when leniency applicants are additionally protected from private damages, firms report cartels more often. So our data confirm the proposal. The policy implication of our study is, thus, that cartel law should probably be amended by increasing the protection from damages of the first leniency applicant to facilitate private action on other cartel members. This is likely to improve both cartel destabilization through stronger leniency-induced temptation to deviate and victim compensation.

One disclaimer is that we only analyze one set of parameters for the damages. Different magnitudes and likelihoods of the damages may lead to different results. Further experiments along this line are promising for future research. Another aspect of private enforcement that is not captured in our experimental design is that buyers have higher incentives to uncover cartels themselves when damage claims are possible. This is a likewise interesting question for future research. Moreover, the treatment of cumulated (and/or higher) fines instead of linear fines and cumulated private damage payments could provide a promising starting point for future research.

[34] Buccirossi *et al.* (2020) further point out the importance of the disclosure of information in the first leniency statement.

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A Appendix

A.1 Variables and theoretical model of the experimental setup

To prove the statements in the main text for the experimental parameters and equilibrium realization of the variables, consider the parameters in table 11. We analyze treatments NOPDC, PDC, and PDC+ in turn.

Definition	Variable	Numerical realization in experiment
Detection probability	ρ	0.15
Damage liability probability	σ	0.95
Discount factor & continuation probability	δ	0.8
Reporting cost	r	1
Marginal cost of production	c	100
Nash price	p_i^n	101
Collusive price	p_i^c	110
Deviation price in NOPDC & PDC	p_i^d	109
Deviation price in PDC+	p_i^d	108
Nash revenue	R_i^n	101/3
Collusive revenue	R_i^c	110/3
Deviation revenue	R_i^d	deviator: p_i^d, others: 0
Nash equilibrium profit	π_i^n	$(101 - 100)/3 = 1/3$
Collusive profit	π_i^c	$(110 - 100)/3 = 10/3$
Deviation profit	π_i^d	deviator: $(p_i^d - 100)$, others: 0
Fine under collusion	F_i^c	$0.1 \cdot R_i^c = 11/3$
Fine under deviation	F_i^d	deviator: $0.1 \cdot R_i^d$, others: 0
Fine under Nash pricing	F_i^n	$0.1 \cdot R_i^n = 10.1/3$
Number of firms that pay damage	N	$\in \{2, 3\}$
Damage payments collusion	D_i^c	$D^c/N = 0.6 \cdot (110 - 101)/N = 5.4/N$
Damage payments deviation	D_i^d	$D^d/N = 0.6 \cdot (p_i^d - 101)/N$
Damage payments Nash	D_i^n	$D^n/N = 0.6 \cdot (101 - 101)/N = 0$

Table 11: Definition of variables and values realized in the experiment.

NOPDC

Following (Bigoni *et al.*, 2015, Appendix A.1), we assume that firms communicate once to establish successful collusion, but are able to collude tacitly following a detection by the competition authority. This implies that cartel firms risk being fined only once on the collusive path. (See footnote 22 above.)

With a probability of detection of ρ, a firm i has to pay a general fine F_i^j depending on outcome $j \in \{c, d, n\}$, with c for collusion, d for deviation and n for Nash. The factor δ discounts future payoffs. The net present value of the fine is obtained as follows: In each period, the cartel is either detected and has to pay F_i^j (happens with probability ρ), or the cartel is not detected (which happens with probability $1-\rho$) but might have to pay the fine in the next period (and accordingly this potential fine has to be discounted by δ). If the next period is reached, the same contingencies arise again, and so on. The stream of potential fine payments reads:

$$E(F_i^j) = \rho F_i^j + (1-\rho)\rho\delta F_i^j + (1-\rho)^2\rho\delta^2 F_i^j + (1-\rho)^3\rho\delta^3 F_i^j + \ldots .$$

Multiplying both sides of the equation with $\delta(1-\rho)$, we have

$$\delta(1-\rho)E(F_i^j) = (1-\rho)\rho\delta F_i^j + (1-\rho)^2\rho\delta^2 F_i^j + (1-\rho)^3\rho\delta^3 F_i^j + \ldots$$

and therefore we obtain

$$E(F_i^j) = \frac{\rho F_i^j}{1-\delta\,(1-\rho)}$$

as an expression for the discounted expected firm-specific fine $E(F_i^j)$.

The *participation constraint* in NOPDC states that colluding must be more profitable than competing (static Nash equilibrium)

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) \quad \geq \quad \frac{\pi_i^n}{1-\delta}.$$

Using the numerical values of the experiment, we find

$$14.948 \quad \geq \quad 1.667.$$

So the participation constraint is met for our experimental setup.

Before analyzing the incentive constraint, we need to analyze whether or not a deviator will report the cartel to the authorities. The deviator will undercut the collusive price with a deviation price of $p_i^d = 109$. Reporting incurs a cost of r and no fine because of leniency. Not reporting saves the reporting cost but involves the risk of the cartel being fined due to detection. The authority may detect the cartel during the period of the deviation (resulting in fine F_i^d) or in a later period when firms play the Nash price as a punishment for the deviation (a cartel formally exists until a cartel member reports it or the cartel is uncovered by the cartel authority). Comparing reporting versus not reporting, we get

$$r = 1 \ < \ \rho F_i^d + \delta(1-\rho)E(F_i^n) = 2.708.$$

That is, a deviator will report.

The *incentive constraint* in NOPDC requires that there should be no incentive to deviate from collusion, given such deviation triggers a return to the static Nash equilibrium price. The incentive constraint accordingly reads

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) \quad \geq \quad \pi_i^d - r + \frac{\delta \pi_i^n}{1-\delta}.$$

Using the experimental parameters, we solve for the minimum discount factor required for collusion and obtain

$$\delta_{min}^{NOPDC} \geq 0.664.$$

This implies that colluding at the highest price of 110 is a subgame perfect Nash equilibrium in our setup. Alternatively, we can plug $\delta = 0.8$ into the incentive constraint and obtain

$$14.948 \quad \geq \quad 9.333$$

with the same implication.

PDC

In the treatment of PDC, the expected fine (has to be paid at most once) and deviation price ($p_i^d = 109$) remains the same. The expected private damages also have to be paid only once (when the cartel busts), but the analysis differs because damages are cumulated over time. The stream of discounted potential damage payments is

$$\begin{aligned} E(D_i^j) \quad &= \quad \rho\sigma D_i^j + (1-\rho)\delta\rho\sigma 2D_i^j + (1-\rho)^2\delta^2\rho\sigma 3D_i^j + (1-\rho)^3\delta^3\rho\sigma 4D_i^j + ... \\ \delta(1-\rho)E(D_i^j) \quad &= \quad (1-\rho)\delta\rho\sigma D_i^j + (1-\rho)^2\delta^2\rho\sigma 2D_i^j + (1-\rho)^3\delta^3\rho\sigma 3D_i^j + ... \end{aligned}$$

Taking the difference $E(D_i^j) - \delta(1-\rho)E(D_i^j)$ yields

$$(1 \ - \ \delta(1-\rho))E(D_i^j) \quad = \quad \rho\sigma D_i^j + \ (1-\rho)\delta\rho\sigma D_i^j + (1-\rho)^2\delta^2\rho\sigma D_i^j + (1-\rho)^3\delta^3\rho\sigma D_i^j + ...$$

and therefore (proceeding as above with steady fines)

$$E(D_i^j) \quad = \quad \frac{\rho\sigma D_i^j}{(1-\delta(1-\rho))^2}$$

which, for the experimental parameters, becomes $E(D_i^j) = 1.3916 D_i^j$.

The *participation constraint* in PDC reads

$$\begin{aligned} \frac{\pi_i^c}{1-\delta} - E\left(F_i^c\right) - E\left(\frac{D^c}{3}\right) &\geq \frac{\pi_i^n}{1-\delta} \\ 12.443 &\geq 1.667. \end{aligned}$$

This participation constraint is also met for the experimental parameters, but it is more severe than the one above under NOPDC since it has less slack. We conclude that private damages deter more cartels.

We obtain the *incentive constraint* in PDC as follows. First, we have to compare the report vs. not report cases. A deviator who reports has to pay the reporting cost, r, and damages $\sigma D^d/3$ whereas a deviator who does not report faces the fine F_i^d and damages $\sigma D^d/3$, with detection probability ρ as well as the expected Nash fine $E(F_i^n)$. For our experimental parameters, we see that reporting is better than not reporting:

$$r + \sigma\frac{D^d}{3} = 2.52 \; < \; \rho F_i^d + \frac{\rho\sigma\frac{D^d}{3}}{(1-\delta(1-\rho))} + \delta(1-\rho)E(F_i^n) = 3.421.$$

The incentive constraint reads

$$\frac{\pi_i^c}{1-\delta} - E(F_i^c) - E\left(\frac{D^c}{3}\right) \quad \geq \quad \pi_i^d - r - \sigma\frac{D^d}{3} + \frac{\delta\pi_i^n}{1-\delta}.$$

Solving for the minimum discount factor required for collusion obtains

$$\delta_{min}^{PDC} \geq 0.655.$$

That is, $\delta_{min}^{NOPDC} > \delta_{min}^{PDC}$. Or, applying $\delta = 0.8$ to the incentive constraint, yields

$$12.443 \geq 7.813.$$

Comparing the minimum disocunt factors (0.664 vs. 0.655), we conclude that PDC makes collusion more stable than NOPDC.

The calculations of the incentives to report are based on the assumption that deviations take place in the first period. For NOPDC, the incentive to report does not change over time as the fine remains unchanged when reporting takes place in later periods. However, in PDC the incentive to report does change. It decreases with the duration of the cartel as damages are cumulated. The highest incentive to deviate is, nevertheless, present in period zero, so the repeated-game incentive constraint above is the one that is relevant when solving the overall game.

PDC+

In the PDC+ case the *participation constraint* remains the same

$$\frac{\pi^c}{1-\delta} - E(F_i^c) - E\left(\frac{D^c}{3}\right) \geq \frac{\pi^n}{1-\delta}$$

because fines and damages for successful collusion do not change compared to PDC (only reporting incentives change).

Again, we first examine the reporting incentives before turning to the incentive constraint. In previous treatments reporting only incurred costs (r) without generating any benefit for non-deviators. Accordingly, only the deviator reports. Instead, in PDC+ non-deviators may benefit from reporting for two reasons. First, by reporting, the non-deviators get the opportunity to eliminate their damage payments. Second, if the non-deviators do not report while the deviator reports, the non-deviators must co-fund the deviator's damage payment ($D^d/3$ increases to $D^d/2$). For our setup, though, it turns out (details available upon request) that deviators will not report, provided the deviator deviates with $p_i^d = 108$. By choosing $p_i^d = 108$ rather than $p_i^d = 109$ the deviator prevents reports by non-deviators and also strongly maximizes the deviation profit. Thus, as in the other treatments, only the deviator reports in PDC+.

The incentive constraint becomes

$$\frac{\pi^c}{1-\delta} - E(F_i^c) - E\left(\frac{D^c}{3}\right) \quad \geq \quad \pi^d - r + \frac{\delta\pi^n}{1-\delta}.$$

In terms of the minimum discount factor required for collusion with a deviation price of 108, we get

$$\delta_{min}^{PDC+} \quad \geq \quad 0.682.$$

Taking the continuation probability of 0.8 into account yields

$$12.443 \quad \geq \quad 8.333.$$

As expected, PDC+ makes collusion more demanding than PDC and NOPDC. That is, PDC+ hinders collusion as intended by the new policy.

A.2 Definitions of variables

Variable	Definition
Propensity to collude	Number of periods in which a subject chooses to enter the communication stage when a cartel does not already exist over the total number of periods in which a cartel does not exist.
Share cartel	Number of periods in which all three subjects of a group choose to enter the communication stage when a cartel does not already exist over the total number of periods in which a cartel does not exist.
Share report	Number of active reports of a cartel (click 'report button') by a group member over all periods that a cartel existed (newly formed cartel or liability from former periods). We exclude periods 10 and 20.
Cartel stability	The number of periods when a cartel was stable divided by the number of cartels of the group. A cartel is stable until it is reported or detected by the authority. We exclude periods 10 and 20.
Cartel prevalence	Number of periods in which a cartel exists (all three subjects of a group choose to enter the communication stage or are liable from former periods) over all periods of a treatment (10 periods).
Ask price non-cartel markets	Average ask price when a cartel does not exist.
Ask price cartel market	Average ask price when a cartel does exist (newly formed cartel or liability from former periods).
Ask price all markets	Average ask price in both non-cartel and cartelized markets.
Market price non-cartel markets	Lowest price of a group when a cartel does not exist.
Market price cartel market	Lowest price of a group when a cartel does exist (newly formed cartel or liability from former periods).
Market price all markets	Lowest price of a group in both non-cartel and cartelized markets.

Table 12: Definition of the main variables.

A.3 Welfare effects and group dynamics over time

In section 4.4 we note that (competitive, cartelized, and all-market) prices decrease in STRUC and increase in CHAT. What could be the intuition for the contradicting price effects in CHAT and STRUC? Figures 12 and 13 yield evidence on the triggers of the contrary effects in prices. In short, they show that prices in STRUC are likely to be lower when private damage claims apply because there are fewer cartels and remaining cartels charge lower prices. Instead, in CHAT the counter-intuitive result is triggered by a hysteresis effect. In CHAT, subjects have the chance to coordinate their behavior even beyond a cartel breakdown and therefore stick to collusive prices until the game ends.

Figures 12 and 13 provide an overview of each group's cartel dynamics in STRUC and CHAT. The blue line plots the binary group dependent variable *collusion*, which is one for a cartelized and zero for a competitive market. The red line shows the course of the market price. The dots mark the cause of the cartel breakdown: The black dot indicates a breakdown due to reporting by at least one firm, the green dot characterizes a breakdown following a detection by the authority. Thus, the graph indicates a stable cartel when the blue line moves along its upper boundary without interruptions by dots. The dashed vertical line in each group-figure marks the switch from the NOPDC to the PDC treatment.

A comparison of figures 12 and 13 shows that the contradicting effects has two main reasons:

i. Prices are overall more **stable** in PDC in CHAT (blue line) compared to STRUC and
ii. prices **remain** at a collusive level after cartel breakdown in CHAT (9 out of 11 groups keep prices at 110 after the cartel breakdown; see group 4, 5, 7, 8, 9, 10, 12, 13, 15), while prices are (by far) less stable in STRUC (exception: group 16). We call the price endurance in CHAT hysteresis.

Figure 12 displays the group dynamics in STRUC. From figure 12, we infer that collusive prices are in most cases below the maximum (that is, 110) and drop even further in the PDC treatment, which leads to a lower mean price for collusive markets. Why does the price for all markets decrease? In combination with fewer cartels in PDC we suggest that cartels are more reluctant to set higher prices in PDC due to the risk of paying damage claims. We conclude that the introduction of private damage claims has positive welfare effects in STRUC. From figure 12, we can also learn that the mean market price for non-collusive markets drops in PDC because some groups manage to increase prices above the collusive level without cartelizing in the first few periods of the game (see e.g., groups 2 and 7).

Figure 13 shows clearly how the possibility to coordinate in a chat fosters collusion and price coordination compared to STRUC such that prices remain at the collusive level even after the collusion is busted. The following communication excerpts confirm our conjectures (translated from the original German):

`- only communicate 1x. EVERYONE ALWAYS 110 NO reporing, more profit is not possible, otherwise we go back to 101 and no one earns anything` (group 3, period 1)

`- everyone 110 in every round` (group 5, period 1)

`- All right. Yes. Always 110, no further communications and no reports.` (group 13, period 1)

Groups coordinate to *always* stick to the collusive price of 110 such that the collusive prices survives the cartel breakdown. It might seem counter-intuitive that hysteresis affects prices in all markets. There is an easy explanation for this: Once a cartel is busted (marked by a black or green dot) the market is identified as competitive even though prices stick to the collusive level. This causes the increase in overall prices and prices in competitive markets. As collusive prices are more volatile in NOPDC (group 2, 11), we observe slightly increasing prices in collusive markets. In contrast to STRUC, cartel prices in CHAT do not decrease after the introduction of private damage claims (e.g., because of the fear of higher damage payments following a detection). We may infer that in the CHAT treatment the introduction of private damage claims has a negative effect on welfare.

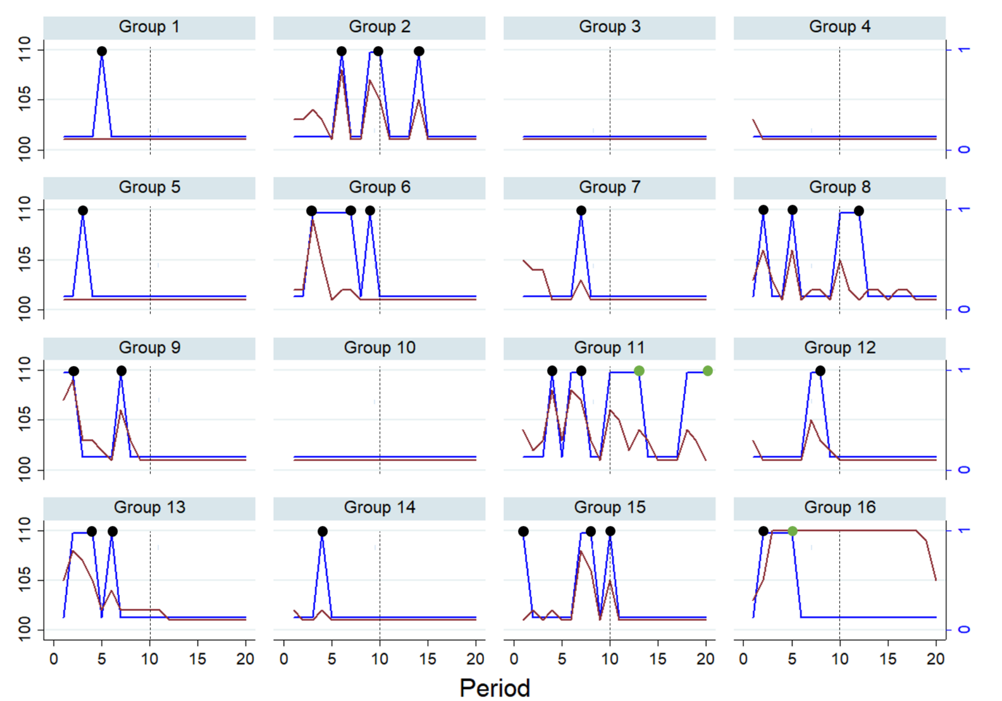

Figure 12: Collusive activity and market price by group for the treatment in STRUC.

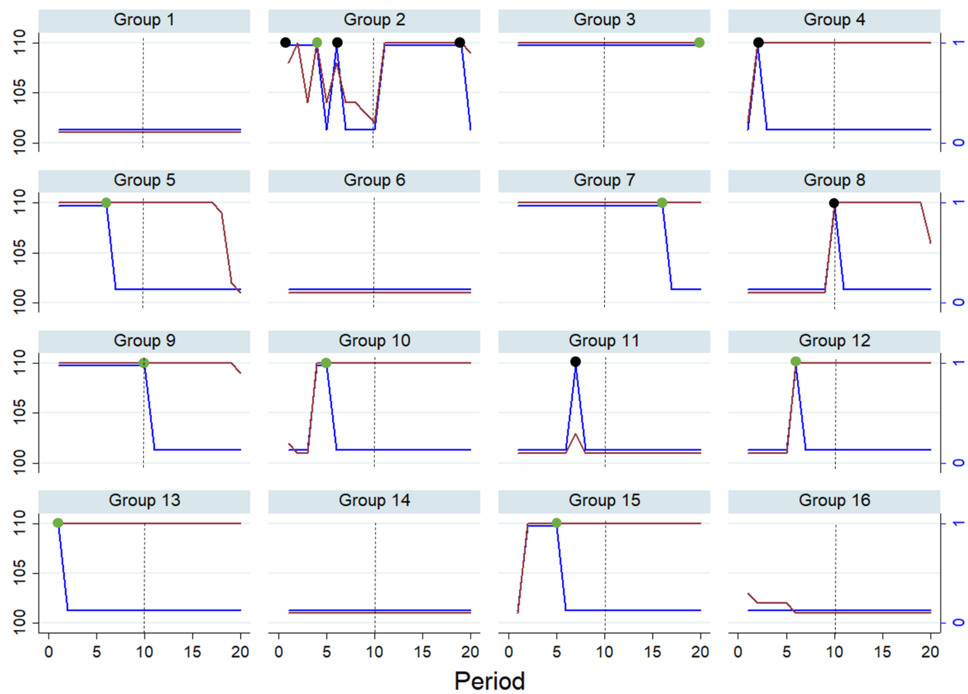

Figure 13: Collusive activity and market price by group in CHAT.

A.4 Deviations from agreed price

Figures 14 and 15 give an overview of the agreed-upon price during the communication stage and the (independently set) ask price. If subjects decide to discuss prices and agree on a single price, this is displayed by the blue line. In STRUC, price discussion can result in an interval of agreed prices. Figure 14 indicates this by the upper and lower bound of agreed prices (see e.g., group 9).

In figure 15, we can observe a more stable price setting following the agreed price even in periods without a cartelized market in CHAT. Figure 14, which considers STRUC, provides an indication of lack of trust in collusive markets (this does not apply to group 16). For example, although group 2 in STRUC agrees on setting a price of 110, all three subjects never simultaneously set the agreed price as their individual ask price, instead they continuously undercut the agreed price. In contrast to that, in figure 15 group 7 gives a perfect example of subjects sticking to the agreed price although prices were not discussed in this period. This behavior emphasizes our explanation of hysteresis regarding subjects not communicating but setting high prices.

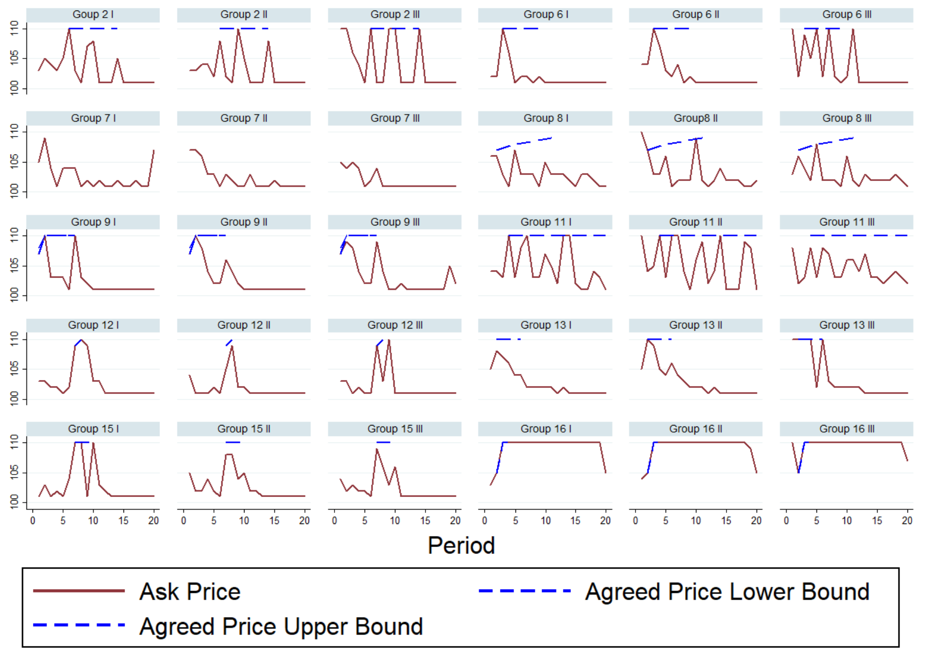

Figure 14: Agreed price and set price by subject in STRUC.
Note: Groups that do not discuss prices or agreed on an interval of 101 to 110 are excluded.

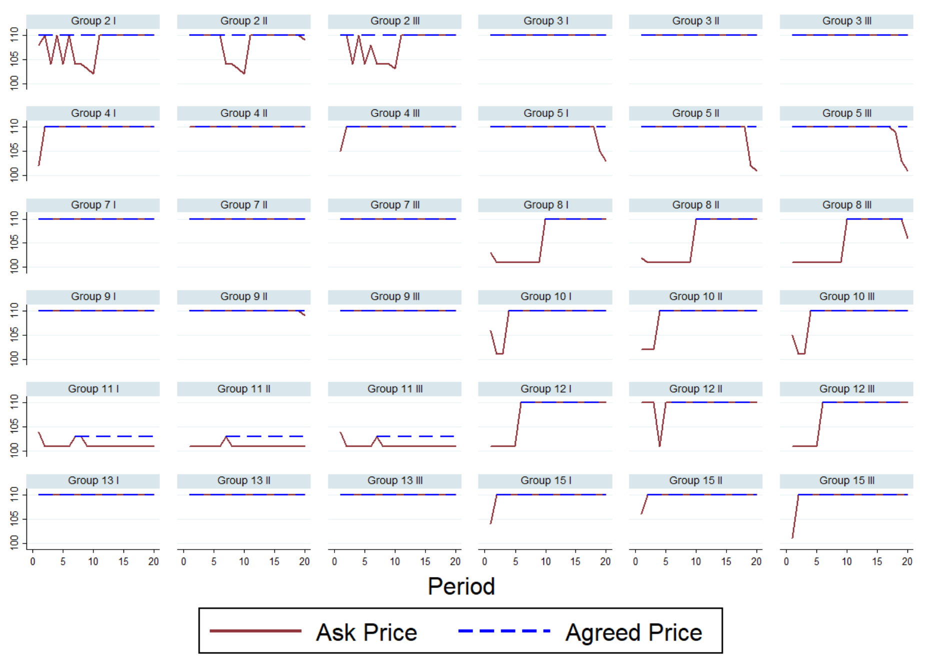

Figure 15: Agreed price and set price by subject in CHAT.
Note: Groups that do not discuss prices or agreed on an interval of 101 to 110 are excluded.

A.5 Ask Prices

In this section we investigate the ask (or offer) price. The ask price is the price firms individually demand in stage 2. Figure 16 (and the bottom line in table 13) illustrate the overall change in ask prices. We see the same pattern as in the above analysis of overall market prices. It shows for treatment STRUC an average overall ask price of 103.67 in NOPDC and 101.94 in PDC. This is statistically significantly different (STRUC: WMP, $p\text{-}value = 0.0011$). The difference in ask prices of NOPDC and PDC in CHAT is not statistically significant (CHAT: WMP, $p\text{-}value = 0.6033$).

	STRUC		CHAT	
	NOPDC	PDC	NOPDC	PDC
Ask price non-cartels	102.885 (1.899)	101.835 (2.125)	105.036 (3.727)	106.700 (4.351)
Ask price cartels	106.158 (2.537)	104.852 (2.727)	109.328 (2.016)	109.989 (0.019)
Ask price all markets	103.669 (2.062)	101.938 (2.162)	106.277 (3.803)	107.110 (4.203)

Table 13: Ask price – averages per treatment (standard deviations in parenthesis).

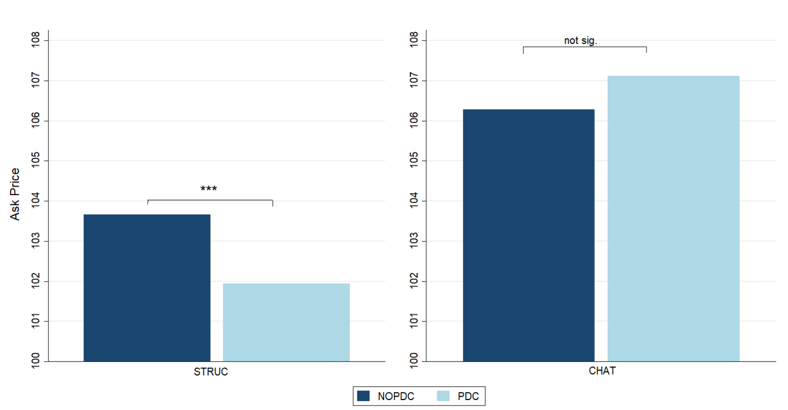

Figure 16: The impact of PDC on ask prices in STRUC (left) and CHAT.

In table 14 we estimate an ordinary least squares (OLS) model with the dependent variable *Askprice* (all markets). The results show that PDC have a negative effect on ask prices in the subsample of STRUC (table 14, column 1), whereas PDC have a positive impact on ask prices in CHAT at a 15% level (table 14, column 2).

	(1) Price	(2) Price	(3) Price	(4) Price	(5) Price
PDC	-1.731***	0.833+	-3.542***	0.458	-0.442**
	(0.317)	(0.573)	(0.460)	(1.046)	(0.201)
constant	103.7***	106.3***	105.0***	106.1***	104.8***
	(0.492)	(0.916)	(0.417)	(0.748)	(0.308)
TIME FE	No	No	Yes	Yes	Yes
Sample STRUC	Yes	No	Yes	No	Yes
Sample CHAT	No	Yes	No	Yes	No
Sample pooled	No	No	No	No	Yes
N	960	960	960	960	1,860
R^2	0.084	0.010	0.116	0.014	0.108

Standard errors in parentheses.
Sample pooled combines data from NOPDC-PDC and PDC-NOPDC.
$^+$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Ask price – linear regression (standard errors in parentheses).

Figure 17 shows the analysis of the sequence of reverse order PDC-NOPDC in STRUC. The robustness check confirms the significantly lower ask prices in PDC (WMU, $p\text{-}value = 0.0785$).

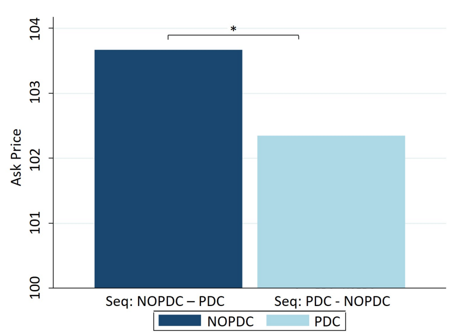

Figure 17: Ask price in STRUC: between-subjects comparison with PDC data from treatment with reverse order (PDC-NOPDC).

A.6 Effect of PDC+ on share to report

Table 15 reports a linear regression of PDC+ on the individual decision to report a cartel in a within-subjects comparison. PDC+ has a significant positive effect on the share of cartel members applying for leniency.

	(1) Report	(2) Report
PDC+	0.222*	0.778***
	(0.126)	(0.141)
constant	0.492***	0.222+
	(0.0756)	(0.141)
Time FE E [Period 1-19, without 10]	No	Yes
Sample STRUC	Yes	Yes
Within Subject	Yes	Yes
N	84	84
R^2	0.037	0.148

Standard errors in parentheses
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: Share report within subject comparison from the treatment PDC-PDC+ linear regression (standard errors in parentheses).

Table 16 shows a linear regression of PDC+ on the share to report a cartel in a between-subjects comparison considering data of PDC from the treatment NOPDC-PDC and data of PDC+ from the treatment PDC-PDC+. Again, the share of applying for leniency significantly increases with PDC+. These specifications only take existing cartels into account for which reason the analyses are based on only a small number of observations.

	(1) Report	(2) Report
PDC+	0.581***	0.490***
	(0.192)	(0.143)
constant	0.133	0.0588
	(0.168)	(0.0440)
Time FE [Period 11-20]	No	Yes
Sample STURC	Yes	Yes
Between Subject	Yes	Yes
N	51	51
R^2	0.350	0.533

Standard errors in parentheses
$^{+}$ $p < 0.15$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Share report between subject comparison with PDC data from NOPDC-PDC and PDC+ data from PDC-PDC+ linear regression (standard errors in parentheses).

A.7 Within-subjects results reverse-order treatment (PDC-NOPDC)

For the robustness check of our main analysis we only use the PDC data from the session PDC-NOPDC (see chapter 4). This allows us to explore any potential order effects, because we only analyze the first 10 periods for both the NOPDC and PDC treatment. For the sake of completeness, table 17 shows an overview of the summary statistics of our reverse-order treatment within subjects. There are no statistically significant differences between PDC and NOPDC in the within analysis of the reverse-order treatment.

	STRUC		Test
	NOPDC	PDC	p-value
Propensity to collude	0.573 (0.193)	0.555 (0.120)	0.7114
Share cartel	0.134 (0.222)	0.117 (0.137)	0.2264
Share report	0.383 (0.267)	0.451 (0.263)	0.5176
Cartel stability	1.611 (0.656)	1.333 (0.476)	–
Cartel prevalence	0.180 (0.283)	0.133 (0.150)	0.4956
Market price	101.2 (0.314)	101.527 (0.680)	0.0364

Table 17: Summary statistics of the results in treatments PDC–NOPDC (STRUC); average results per treatment (standard deviations in parentheses).

A.8 Controlling for order effects – Between-subjects results across treatments

For the robustness check of our main analysis we only use the PDC data from the session PDC-NOPDC (see chapter 4). This allows us to explore any potential order effects, because we only analyze the first 10 periods for both the NOPDC and PDC treatment. For the sake of completeness, we also control for order effects within the same treatment under different time regimes. We analyze whether our main variables of interest are significantly different under each treatment, when this treatment is run in periods 1-10 rather than 11-20. We test this by conducting a Mann-Whitney U test (one per treatment) across the two samples. Tables 18 and 19 show an overview of the summary statistics of our between-subjects comparison across treatments. Lots of our main variables show no differences. This suggests that order effects are no major concern. Additionally, we formally control for possible order effects by using pooled data for our regressions in section 4 tables 5 to 10. These results provide further evidence that there are no order effects.

	NOPDC		Test
	NOPDC -1st half	NOPDC 2nd half	p-value
Propensity to collude	0.619 (0.142)	0.573 (0.193)	0.4733
Share cartel	0.207 (0.153)	0.134 (0.222)	0.0847
Share report	0.462 (0.230)	0.383 (0.267)	0.5454
Cartel prevalence	0.238 (0.178)	0.180 (0.283)	0.1272
Market price	102.706 (2.009)	101.2 (0.314)	0.0059

Table 18: Summary statistics of the results across different time regimes NOPDC (STRUC); average results per treatment (standard deviations in parentheses).

	PDC		Test
	PDC -1st half	PDC 2nd half	p-value
Propensity to collude	0.555 (0.120)	0.394 (0.192)	0.017
Share cartel	0.117 (0.137)	0.019 (0.054)	0.0124
Share report	0.451 (0.263)	0.296 (0.339)	0.4525
Cartel prevalence	0.133 (0.150)	0.063 (0.163)	0.0671
Market price	101.527 (0.680)	101.681 (2.095)	0.1533

Table 19: Summary statistics of the results across different time regimes PDC (STRUC); average results per treatment (standard deviations in parentheses).

A.9 Within-subjects results for the main variables (PDC-PDC+)

For the sake of completeness, table 20 shows an overview of the summary statistics of our main variables from our PDC-PDC+ treatment with an MWU within-subjects test. The share of cartelized markets, cartel prevalence as well as the market price are significantly smaller under the PDC+ regime.

	STRUC		Test
	PDC	PDC+	p-value
Propensity to collude	0.501 (0.243)	0.467 (0.243)	0.4688
Share cartel	0.132 (0.130)	0.044 (0.081)	0.0261
Share report	0.430 (0.224)	0.6889 (0.241)	0.1655
Cartel prevalence	0.138 (0.131)	0.044 (0.081)	0.0239
Market price	103.456 (3.122)	102.313 (2.826)	0.0041

Table 20: Summary statistics of the results across different time regimes PDC (STRUC); average results per treatment (standard deviations in parentheses).

In order to control for any possible order effects we use the PDC data from the session NOPDC-PDC and the PDC+ data from the session PDC-PDC+ (see chapter 5 figure 11). In this approach, we only analyze the last 10 periods for both the PDC and PDC+ treatment. Due to special circumstances arising from the 'Corona pandemic' we control whether the sessions before and during the 'Corona pandemic' are significantly different from each other. We test this by conducting a Mann-Whitney U test between the PDC treatment from the session PDC-NOPDC and the PDC treatment from the session PDC-PDC+. Table 21 shows an overview of the summary statistics of our between-subjects comparison across treatments. For all our main variables of interest there is no statistically significant difference leading to a conclusion of no 'Corona pandemic effects'. This result supports our between-subjects comparison in figure 11.

	STRUC		Test
	PDC 1st half (PDC-NOPDC)	PDC 1st half (PDC-PDC+)	p-value
Propensity to collude	0.555 (0.120)	0.501 (0.243)	0.8896
Share cartel	0.117 (0.137)	0.132 (0.130)	0.7271
Share report	0.451 (0.263)	0.430 (0.224)	0.8327
Cartel prevalence	0.133 (0.150)	0.138 (0.131)	0.9016
Market price	101.527 (0.680)	103.456 (3.122)	0.0400

Table 21: Summary statistics of the results across different time regimes PDC (STRUC); average results per treatment (standard deviations in parentheses).

A.10 Instructions

Instructions for the experiment with structured (chat) communication (translated from German):

Welcome to our experiment.

Please read these instructions carefully. Please do not talk to your neighbor and we ask that you remain quiet throughout the experiment. If you have any questions, please raise your hand. We will come to your place and answer your question in private. In this experiment, you have to take decisions repeatedly. In the end, you can earn money. How much you earn depends on your decisions and the decisions of two other participants who have been randomly assigned to you. At the end of the experiment, you will receive your earnings in cash. All participants receive (and are reading) the same instructions. You will remain completely anonymous for us and for the other participants. We do not store any data connected with your name.

Overview:

The experiment lasts for at least 20 periods, each period consists of seven steps. These steps are the same in each period. Below, you will find an overview of the experiment as well as an explanation of all seven steps of each period.

At the beginning of the experiment, all participants will be randomly assigned into groups of three. The group composition will not change during the experiment. Group members remain anonymous. During the experiment you will have no contact to participants of the experiment outside your group.

You can collect points in any period of the experiment. At the end of the experiment these points will be converted into euros, where: $1\ point = 0.3\ euros$. At the beginning of the experiment you will receive a starting capital of 15 points. At the end of each period, all the points collected during that period will be credited to your account. If you score a negative number of points in a period, this number of points will be deducted from your starting capital.

Like the other two group members, you are a supplier of the same good in a market. In each period you must choose a price for the good. This price must be one of the following: 101, 102, 103, 104, 105, 106, 107, 108, 109 or 110. You and the other two group members will choose the price at the same time.

You only earn points if your price is the lowest of the three prices. Your profit will then be equal to your price minus the cost of 100. However, if one or both other group members have chosen the same lowest price, you must share the profit with them.

It is possible to discuss the price you want to set. Price discussion is only possible if all group members agree to discuss the prices. If there has been a communication about prices, you might risk some points being deducted later, either through reports from the group members (step 5) or a random move (step 6).

Each period has seven steps. Below is a more detailed explanation of each step.

In step 1 of each period the following question is asked: ”Do you want to discuss the price with your group members? To answer this question, press the ”DISCUSS PRICE” or ”DO NOT DISCUSS PRICE” button. The other two group members will make the same decision at the same time.

Only if all group members press the button ”DISCUSS PRICE,” a communication window opens and step 2 (the communication phase) will begin. If one or more group members click on the button ”DO NOT DISCUSS PRICE” there will be no communication. In this case step 2 (the communication phase) will be skipped and you will proceed to step 3 (the pricing phase).

If a communication has taken place, there is a risk that points will be subtracted from your account in step 5 or 6. See below.

Step 2: Communication. After opening the communication window, you can talk about the price as explained in the following: You can choose a minimum price and a maximum price that is acceptable to you from the following price range: 101, 102, 103, 104, 105, 106, 107, 108, 109, 110. If only one price is acceptable to you, choose the same value for the minimum price and the maximum price.

If all group members have chosen their minimum price and maximum price, each group member is informed about the overlap of the three price ranges. If the overlap consists of one price, this is the agreed price and step 2 is completed.

If there is no overlap, this procedure is repeated until the overlap consists of only one price or 60 seconds have passed. If no price agreement is reached after 60 seconds, the discussion screen closes. In this case, the last overlap is the agreed price interval.

Communication about anything other than the price is not possible.[35]

Step 3: Pricing phase. You chose your market price. You are again restricted to prices from 101 to 110. The other two group members will make the same decision at the same time. Results of any communication are not binding.

Step 4: Market price. In step 4, you learn the market price that has been set in your group. The market price corresponds to the lowest entered price in step 3 in your group. You only earn points if your price is the lowest of the three prices.

The revenue corresponds to the market price without a reduction of costs (100):

- If your price is the lowest price and no other group member has chosen the same price: Revenue = market price.
- If the price you chose is the lowest price and one other group member has set the same price: Revenue = market price / 2.
- If the price you have chosen is the lowest and the other two group members have set the same price: Revenue = market price / 3.
- If your price is not the lowest price: Revenue = 0.

Your profit corresponds to the market price after the deduction of costs (100):

- If your price is the lowest and no other group member has chosen the same price: Profit = market price - 100, i.e., you alone get the profit.
- If the price you chose is the lowest and one other group member has set the same price: Profit = (market price - 100) / 2, that is, you both share the profit.
- If the price you chose is the lowest and the other two group members have set the same price: Profit = (market price - 100) / 3, that is, you share the profit with the two other group members.
- If your price is not the lowest: Profit = 0 points.

The experiment continues with step 5 (reporting decision) when a communication about prices in step 1 has taken place. If not all group members have agreed to a communication in step 1, the experiment will continue with step 7 (end of period).

Step 5: Point deduction through reporting. If communication has taken place, you must decide in this step whether you want to report the communication. You can report price discussion

[35] The instructions for the CHAT treatment differ from the STRUC-instructions with respect to step 2. The CHAT-instructions read the following: After opening the communication window, you can discuss the price with your group members by entering a text in the communication field and pressing Enter. During the communication you remain anonymous. The communication window closes after 60 seconds. After the communication window has closed, communication in the current period is no longer possible.

by pressing the ”REPORT” button. If you do not want to report, press the ”DO NOT REPORT” button. The other group members must take the same decision at the same time. Reporting always costs one point.

Step 5 only takes place if (i) there was a communication in the current period or (ii) there was a communication in one or more of the previous periods and since then none of the group members pressed the REPORT button and no point deduction by a random move (step 6) has taken place.

After a communication has been reported by you or one of your group members, the ability to report in future periods will expire until the communication about prices is renewed.

In the event of one or more group members reporting the communication, each group member will receive a point deduction of the following amount: The point deduction generally is 10% of your revenue in that period.

If you report the communication, your point deduction can be prevented or reduced in the following:

- You will not receive a point deduction if you are the first to press the REPORT button.
- If you are the second to press the REPORT button, your point deduction is cut by half.
- If you are the third to press the REPORT button, your point deduction will not be reduced.

The experiment will continue with step 6 (random draw) if all group members have pressed the ”DO NOT REPORT” button. If one or more group members have reported the communication, the experiment continues with step 7.

Step 6: Points deducted by random draw. In this step, a random draw decides whether points will be deducted from you and your group members' account. The probability of a point deduction is 15%; with an 85% probability no points will be deducted.

Step 6 will only take place if (i) there has been communication about prices in the current period and there has been no random point deduction, or (ii) there has been communication in one or more of the previous periods and since then none of the group members pressed the REPORT button and no random point deduction has taken place so far.

After the random draw you will be informed whether you and your group members received any point deductions in that period.

If there is a point deduction by a random draw, the point deduction will be 10% of your current period revenue.

If the random draw results in point deduction, there will be no further point deductions again until communication is renewed and (i) and (ii) are fulfilled (see above).

Step 7: Period End. In this step you will receive the information of your accumulated points from the current period and from previous periods. The total score (the sum of the points from all periods played) is also displayed. Your accumulated points in the current period correspond to your profit after possible point deductions:

Accumulated points in a period = profit - possible deduction of points

The points are calculated in the same way for each group member. Your points will be credited to your point account after each period. If there has been a deduction of points, the reason for the deduction of points (report or random draw) is shown for all group members.

Next step: Sudden change of rules. In the course of the experiments, there may be a rule change. You will be informed of such a change at the appropriate point.

New period: You play at least 20 periods. From period 20 the experiment ends at the end of each period with 20% probability. With a probability of 80% the next period will start with step 1.

Instructions for the change of rules in period 10 for the introduction of PDC (translated from German):

Introduction of step 8: In addition to the point deduction in step 6, there is now a 95% probability that there will be another point deduction if:

1.) you or some other of your group members have reported the communication, or
2.) in step 6, chance decides that you and your group members will receive a deduction of points.

This point deduction is in addition to the point deduction from step 6 which covers 10% of your current period revenue. The additional point deduction for each group member is 20% of the difference between the group's market price and 101 (the lowest price to choose). The point deduction is added up over all periods in which you communicated but the communication was not discovered or reported.

Instructions for the change of rules in period 10 for the introduction of PDC+ (translated from German):

Change of the second point deduction in step 8: The second point deduction can now be reduced:

The amount of the second point deduction can now be either 20% or 30% of the difference between the market price and 101 (the lowest price to be chosen). The second point deduction differs in the cases of random draws and reporting by a group member as follows:

1.) if the random draw decides in step 6 that points will be deducted from you and your group members' account, the second point deduction will still be 20% of the difference between the market price and 101 for all group members. The point deduction is added up over all periods in which you communicated but the communication was not discovered or reported.
2.) if you or one or more of your group members reported the communication in step 5, the second point deduction will be different for each group member. The point deductions for group members due to reporting are as follows:
   - Points will not be deducted from your account if you are the first group member to press the REPORT button.
   - If you are the second or third group member to press the REPORT button or do not press the REPORT button at all, the second point deduction in step 8 is 30% of the difference between the market price and 101. The point deduction is added up over all periods in which you communicated but the communication was not discovered or reported.

The reduction of the first point deduction by reporting in step 5 remains unchanged.

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