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RESEARCH ARTICLE

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Blowing the whistle

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Abstract Leniency clauses, offering cartelists legal immunity if they blow the whistle on each other, is a recent anti-trust innovation. The authorities wish to thwart cartels and promote competition. This effect is not evident, however; whistle-blowing may enforce trust and collusion by providing a tool for cartelists to punish each other. We examine the impact of leniency law, and other rules, experimentally.

Keywords Anti-trust · Leniency · Immunity · Amnesty · Blow the whistle · Cartels · Price competition · Bertrand model · Experiment communication

JEL Classification Numbers C92 · D43 · L13

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1 Introduction

Governments actively fight cartels. It is illegal for firms to agree to fix prices, or even to engage in discussions, the presumption being that pricing conspiracies will ensue. In the United States this is regulated in the *Sherman Act*, dating back to 1890 (see Hovenkamp 2000; Scherer and Ross 1990). Many other countries enacted similar laws in the twentieth century.

A recent innovation in anti-trust regulation is to guarantee immunity from prosecution to cartelists who report to the anti-trust authority a cartel in which they are taking part. The US Antitrust Division created such a "Leniency policy" (also referred to as "Amnesty Program" or "Corporate Immunity Policy"), first in 1978 and then refined and extended in 1993. Many other countries have since adopted similar schemes, and collaboration within the *OECD Competition Committee* continuously fosters correlated development of anti-trust legislation throughout the OECD country members.[1] The European Commission, for example, introduced leniency rules first in 1996, and subsequently in 2002, when a legislation, which closely mimics the US policy, was adopted. A press release announced this as follows (European Commission 2002a; emphasis added by us):

> The European Commission … took another important step to uncover and suppress price-fixing pacts and other hard-core cartels. The Commission unanimously adopted a new leniency policy that creates greater incentives for companies to *blow the whistle* on the most serious violations of antitrust rules. Under the new rules the Commission will grant *total immunity from fines* to the first company to submit evidence on a cartel unknown to, or unproved by the Commission.

The press release quotes Competition Commissioner Mario Monti as follows, reflecting some objectives and conjectures of the legislator (our emphasis):

> [T]he new policy will *increase the likelihood that cartels will be detected* which, together with the Commission's determination to impose fines at dissuasive levels, *should deter companies from entering into collusive behaviour* in the first place.

The new legislation is furthermore motivated with reference to "the experience of the United States", which is taken to be a success. This positive judgement is shared by the US Department of Justice, as reflected in the report by Spratling (1996, p. 2), Deputy Assistant Attorney General of the US Antitrust Division:

> The early identification of antitrust offences through compliance programs, together with the opportunity to pay zero dollars in fines under the Division's Corporate Amnesty program, has resulted in a "race to the courthouse,"…

A legally sanctioned opportunity for costless whistle-blowing changes the nature of the game played in the marketplace. However, as first noted and theoretically elaborated on by Motta and Polo (2003) and Spagnolo (2000a,b), it is not obvious

[1] See OECD Competition Committee (2002), a collection of reports that articulates anti-trust goals and which gives details about the leniency programs in the US, the UK, Canada, and the EU.

that the effect will be to thwart cartels. Consider the following argument: Cartel agreements are illegal, and must therefore rely on trust rather than written contracts. A colluding firm must therefore reckon that a fellow cartelist may cheat on a price fixing agreement. In this connection, whistle-blowing may be a useful tool. If a firm deviates from a cartel agreement, a fellow cartelist may retaliate by reporting the deviator to the anti-trust authority. Therefore, deviations from cartel agreements may be discouraged, and the propensity to join cartels therefore enhanced, so that collusion may be fostered!

It is not easy to judge these matters by mere observation of market data. There is the informational problem that undetected cartels cannot be observed, and the counterfactual problem that one cannot know how a market would have operated with some other anti-trust policy. Against this background we attempt to shed light on the impact of leniency policy, and various alternative anti-trust policies (which have either been used historically or which may have interesting properties), in an experiment. We first propose a few market games, which pinpoint and isolate key features of some anti-trust policy, and for which we derive predictions which are contrasted to the views of the world held by competition authorities. We then examine these market games experimentally, testing whether the predictions and the effects envisioned by anti-trust authorities obtain.

The nature and complexity of naturally occurring markets varies. Which particular characteristics should be addressed in an experiment? We believe ours is the first laboratory study of leniency policy, so it seems natural to focus on a simple context derived from a well understood basic model. We explicitly incorporate opportunities for cartel communication, payments reflecting different forms of anti-trust policy, and opportunities for whistle-blowing, and these three features seem to us a tall enough order that it makes sense to simplify the design as much as possible in other ways. Therefore, apart from incorporating the just-mentioned three features, we build on the simplest possible one-shot Bertrand model of price competition we could conceive of. We leave aside important extensions of that model involving for example heterogeneous goods, incomplete information, or repeated interaction.

The market games, experimental material (procedures, hypotheses, results), connections to related literature, and our conclusions appear in Sections 2, 3, 4, and 5, respectively.

2 The market games

Textbook versions of the Bertrand model often admit infinitely many strategies,[2] but we consider a discretized version similar to that introduced by Dufwenberg and Gneezy (2000). The theoretical analysis, and the subsequent experimental design, evolves around augmented versions of the following game:

- There are three firms.
- Each firm simultaneously chooses a price in the set {91, 92, . . ., 100}.

[2] For textbook discussions of Bertrand models, see (Tirole, 1994, pp. 209–18) and Vives (1999, ch. 5).

- The firms choosing the lowest price divide among themselves a profit equal to the difference between this price and 90. The other firms earn nothing.

This market game captures the following assumptions: Consumer demand is completely inelastic for prices up to the consumers' maximum willingness to pay, which equals 100. The quantity demanded is (normalized to) one (divisible) unit. The per unit production cost is 90. (The particular 90/100-parameterization is chosen on the grounds that it accords well with the rule for "fines", to be described below under the heading "STANDARD".)

The game possesses a unique Nash equilibrium. In this equilibrium each firm chooses a price of 91. The profit to each firm is $(91-90)/3 = 1/3$.

We next discuss four modifications of this model, which capture particular anti-trust legislations. Each modification corresponds to one experimental treatment. We shall refer to these four models, as well as to the corresponding experimental treatments, as STANDARD, LENIENCY,BONUS, and IDEAL. All but the last of these have a non-trivial dynamic structure, and it is natural to apply the solution concept of subgame perfect equilibrium.

2.1 STANDARD

The idea that discussions among firms fosters collusion goes back at least to Adam Smith. In Book I of *The Wealth of Nations*, he writes:

> People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices.

Modern anti-trust legislation takes a similar outlook. Documented *meetings* between competitors is taken as (full or partial) evidence of a *cartel*. Because of problems regarding observability, provability, or measurability, it is to a large extent the occurrence of a meeting itself rather than the content of what was said or the nature of the agreement struck or the resulting inefficiency in the marketplace that is the basis of legal action. See Hovenkamp (2000) for a discussion.

One may imagine that an authority learns about cartels through own investigation, through third party reports, or through the cartel members themselves. We shall disregard the former two possibilities, and focus exclusively on the last possibility (in all models we derive).

The market game STANDARD *is an attempt to capture the essence of the law prior to the introduction of leniency clauses*. This is a three-stage game with observed actions. In stage one, each firm chooses whether or not it wishes to join a cartel. A cartel, involving non-binding communication between the involved parties, is arranged if and only if *all* firms wish to have a cartel. In stage two, each player chooses a price in the set $\{91, 92, \ldots, 100\}$. Stage three occurs if and only if a cartel was formed in stage one. In stage three, each firm considers whether or not to report the cartel.

The firms' payoffs depend on their price choices just as in the previously discussed model of Bertrand price competition, *except that the payoffs may be modified by fines*. Fines have to be paid if and only if a cartel was formed and some firm reported the cartel. In this case, each firm must pay a fine equal to 10% of its

revenue.[3] This 10% *rule* is adopted from the current legislation of the European Union.[4]

In order to enhance the feel for the payoff structure, it may be helpful at this point to consider an example. We exhibit a particular path of play, chosen merely on the basis that it displays key features of the payoff function. We will reconsider this path each time we introduce a new model.

Example 1: In stage 1 each firm expresses its wish to join a cartel. In stage 2, firms 1 and 2 choose a price of 97 while firm 3 chooses 99. In stage 3, firms 2 and 3 report the cartel. The payoffs of firms 1 and 2 will be $(97-90)/2-0.10\times 97/2 = -1.35$. The payoff of firm 3 will be $0-0.10\times 0 = 0$. Note that the path of play described is not the result of an equilibrium strategy profile (*e.g.*, either player can gain by not agreeing to join a cartel, and then choosing 91).

The payoff function in STANDARD has the following properties: Collusion in a cartel is beneficial to the firms only if (i) it helps them achieve higher prices, and (ii) their cartel is not subsequently detected. The firms never profit from being in a detected cartel; the 10% rule, coupled with the underlying assumptions about production costs and demand (the 90/100-parameterization described in the beginning of section 2), ensure that profits never exceed fines. It is better to abstain from joining a cartel than to be caught in one. The underlying assumption is that the legislation is not so lax that it is trivially in a firm's interest to join a cartel. We felt that these properties were reasonable to include in the experiment, and consequently some key parameters of the design (the 10% rule and the 90/100-parameterization for prices) were chosen so as to achieve this.

STANDARD has multiple (subgame perfect) equilibria. We focus on describing the key features of the patterns of play admitted. Most importantly, *any symmetric price vector is sustainable in equilibrium.* There are equilibria where no cartel forms (because they would be reported), and each firm chooses a price of 91. Other equilibria involve successful collusion. The following example describes an equilibrium resulting in collusion at the highest possible price (equilibria involving cartel formation and symmetric pricing at lower levels can be described analogously).

Example 2 (*collusive equilibrium*): In stage one each firm indicates that it wishes to have a meeting with the other two firms. Thereafter, each firm chooses a price of 100 and does not report unless some other firm chooses a price below 100. If (outside the equilibrium path) some firm decides against having a meeting, then each firm chooses a price of 91.

The path of play described by this equilibrium entails cartel formation, pricing at the highest possible level, and no cartel reporting. Note that if a firm were to

[3] The revenue of a firm choosing the lowest price equals that price, divided by the number of firms choosing that price. For any other firm, the revenue is zero.

[4] See European Union (1998); European Commission (2002b). Our implementation is an approximation of the law, which distinguishes "minor" and "very serious infringements", and which may involve fixed components. The law stipulates a "limit (on fines) of 10% of all (yearly) turnover". Our implementation adopts the ten percent cap, and applies it as if the revenue of our games corresponded to entire yearly turnover. We note that the theoretical conclusions we obtain may be sensitive to these modeling details; see, e.g., Spagnolo (2000a) for results that bear this out.

deviate, undercutting the others with a price of 99, its payoff (given that the others stay with their equilibrium strategies) would be -0.9, which is strictly less than 10/3, the payoff from sticking to the equilibrium strategy.

Our conclusion: STANDARD *may sustain collusion with high prices.*

2.2 LENIENCY

The market game LENIENCY works just like STANDARD, *except in terms of how fines are determined after a cartel is formed*. If one firm reports the cartel, then this firm pays no fine, while each of the other two firms pays 10% of its revenue. If two firms report the cartel, then each of these firms pay a fine of 5% of its revenue, while the third firm pays 10% of its revenue. If all three firms reports the cartel, then each firm pays a fine of 6.67% of its revenue.

Relative to STANDARD, LENIENCY offers a fine reduction to a reporting firm; the fine is eliminated, cut in half, or reduced by one third, depending on the number (one, two, or three) of whistle-blowers. These rules roughly follow the practice of partial immunity clauses applied by the antitrust authorities if more than one cartelist blows the whistle at about the same time (see, e.g., European Commission 2002a; Joshua 2003).

Example 3: In stage 1 each firm expresses its wish to join a cartel. In stage 2, firms 1 and 2 choose a price of 97 while firm 3 chooses 99. In stage 3, firms 2 and 3 report the cartel. The payoff of firm 1 will be $(97-90)/2-0.10\times 97/2=-1.35$. The payoff of firm 2 will be $(97-90)/2-0.05\times 97/2=1.075$. The payoff of firm 3 will be $0-0.05\times 0=0$. The path of play described is not the result of an equilibrium strategy profile (*e.g.*, either player can gain by not agreeing to join a cartel, and then choosing 91).

LENIENCY strengthens the incentives for whistle-blowing. One may expect, therefore, that collusion is avoided at equilibrium. However, the structure of the set of (subgame perfect) equilibria remains essentially unchanged relative to STANDARD. Again, *any symmetric price vector is admitted as part of an equilibrium.* As an illustration, the strategy profile described in Example 2 forms a collusive equilibrium in LENIENCY exactly as in STANDARD.

The claim that LENIENCY may sustain cartels and high prices is less convincing than the analogous claim for STANDARD, however. In LENIENCY, any equilibrium involving the formation of a cartel will entail the use of weakly dominated strategies. In LENIENCY, unlike in STANDARD, a cartelist can never be made worse off by blowing the whistle and may be better off.

Our conclusion: LENIENCY *may sustain collusion with high prices, but the case for this to happen is weaker in* LENIENCY *than in* STANDARD.

2.3 BONUS

Given the finding that LENIENCY need not be unambiguously successful in avoiding cartels and inducing competitive behavior, it is natural to think of alternative schemes which theory would suggest achieve that end. Spagnolo (2000a) and

Aubert et al. (2003) theoretically show that the implementation of a bonus system may provide a powerful enough tool to deter the formation of cartels. In this line, we consider a scheme which is identical to LENIENCY in terms of how fines are determined, but which adds the rule that *all the whistle-blowers get to share among themselves all the fines paid by the non-reporting cartelists*. That is: A lone whistle-blower pays no fine and collects the fines paid by the other two as a bonus. With two whistle-blowers, each of them pays a fine of 5% of its revenue and collects half the fine of the third firm as a bonus. When all three firms blow the whistle each of them pays a fine of 6.67% of its revenue, and no bonuses are collected.

Example 4: In stage 1 each firm expresses its wish to join a cartel. In stage 2, firms 1 and 2 choose a price of 97 while firm 3 chooses 99. In stage 3, firms 2 and 3 report the cartel. The payoff of firm 1 will be $(97-90)/2-0.10\times 97/2=-1.35$. The payoff of firm 2 will be $(97-90)/2-0.05\times 97/2+(0.10\times 97/2)/2=3.50$. The payoff of firm 3 will be $0-0.05\times 0+(0.10\times 97/2)/2=2.425$. The path of play described is not the result of an equilibrium strategy profile (*e.g.*, player 1 can gain by not agreeing to join a cartel).

BONUS strengthens the incentives for whistle-blowing further, and the structure of the set of (subgame perfect) equilibria changes dramatically. In fact, in equilibrium no cartel is formed, and each firm chooses a price of 91, the most competitive price. These findings are consistent with those in the literature (see Spagnolo 2000a; Aubert et al. 2003).

To see that collusion is ruled out, consider the subgame after each cartelist has indicated that it wishes to enter a cartel. First, note that following any symmetric price choice vector, to blow the whistle it is a strictly dominant choice for each firm (in the relevant subgame), and the consequence would be negative profits to all firms. Second, following any other asymmetric price choice vector, if there is a low price seller who does not blow the whistle then it is a best reply for a high price seller to blow the whistle. Given this, it is a best reply for the low price sellers to report. Thus no bonuses are collected, and hence high price sellers get zero profits. Finally, note that not joining the cartel in the first place, and pricing at the minimum level assures strictly positive payoff.

Our conclusion: BONUS *preclude cartels, and induces competitive pricing.*

2.4 IDEAL

All the preceding models take seriously the idea that firms may meet and discuss prices. That option would seem relevant, as a de facto opportunity, in most naturally occurring markets. However, a casual glance at texts produced by competition authorities suggests that they *would like to* block this option. As a yard-stick for measuring the 'success' of anti-trust policy, it is then natural to consider what would happen if cartel meetings were outright impossible. These are the conditions in IDEAL.

The resulting model is identical to the benchmark Bertrand game, discussed in the beginning of this section. In the name of presentational completeness, we again illustrate despite the simplicity of the game:

Example 5: Firms 1 and 2 choose a price of 97 while firm 3 chooses 99. The payoff of firms 1 and 2 will be $(97-90)/2=3.50$. The payoff of firm 3 will be 0. The

Table 1 The four market games

Game	Key Features	Equilibria
STANDARD	Three stages; no fine reductions; no bonuses	All symmetric price vectors
LENIENCY	Three stages; leniency; no bonuses	All symmetric price vectors
BONUS	Three stages; leniency; bonuses	(91,91,91)
IDEAL	One stage; no possibility of cartels	(91,91,91)

path of play described is not the result of an equilibrium strategy profile (e.g., either player can gain by choosing 96).

There is only one stage where firms choose prices. In the unique equilibrium of the game, each firm chooses a price of 91. The profit to each firm is $(91 - 90)/3 = 1/3$.

Our conclusion: IDEAL *induces competitive pricing.*

2.5 OVERVIEW

Table 1 gives an overview of our market games, highlighting key features.

3 The experiment

3.1 Procedures

The experiments were run at the Laboratory for Experimental Economics at the University of Bonn. The computerized program was developed using RatImage (Abbink and Sadrieh 1995). We had 12 groups of 3 participants in each of the 4 treatments, except in LENIENCY where we had 16 groups of three participants.[5] Hence, a total of 156 participants took part in the experiment.

Earnings, derived from the payoff numbers in the previous section, were recorded in Taler (the experimental currency). Talers were convertible to Euros at the rate of 2 Euros per Taler.[6] Average earnings in the experiment were €11. The treatments differed in terms of the number of stages involved in the games played, and the complexity of the associated instructions. Therefore sessions varied in length from 20 min in the case of IDEAL (where the game has one stage and the instructions were simple) to one hour in BONUS(where the game has three stages and the instructions were more complicated).

When participants arrived at the laboratory they were seated in a lecture room where the instructions (see Appendix 1) were introduced and questions answered. The participants were then randomly assigned to visually isolated cubicles equipped with computer terminals. There they had to answer a detailed questionnaire (see

[5] In planning the experiment we scheduled one extra session, in case some problem would occur. As explained below, we 'lost' one LENIENCY observation, as a group of subjects violated the instructions. Hence, we decided to devote the extra session to LENIENCY, which explains why we have the highest number of observations in that treatment.

[6] At the time the experiments were run €1 approximately corresponded to $1.

Appendix 2) on the rules of the game they were about to participate in. The experiment did not proceed until all participants had correctly answered all questions.

Then play started. Except for IDEAL (where participants directly entered the price competition stage), the first decision stage in all treatments was the communication stage. In the communication stage participants had to simultaneously decide whether they would like to have a meeting with the other two members of the group. The instruction made it clear that there would be a meeting if and only if all three members decided that they would like to have a meeting, and that having a meeting meant joining a cartel. They were also informed that a meeting would be organized as a computerized chat that would last for 10 minutes.

After all players decided whether they would like to have a meeting, they were informed whether a meeting would take place. In that case the chat was started. The only restriction imposed on communication was that it was forbidden for participants to reveal their identity in any way. This rule was broken by one group (group 11 in LENIENCY). As a consequence, we exclude this group from the analysis of price choices and cartel reports.

After the chat was completed, the price competition stage begun. Each participant simultaneously chose a price, which was an integer in the range of 91–100. Once all players had made this choice, each one got information on the prices chosen by the two other players in the group, and on their own profit. All of this was explained to the participants in the instructions.

After the price competition stage, the experiment was over for participants in IDEAL, as well as those groups in the other treatments that did not have a meeting. The other groups (in STANDARD, LENIENCY, and BONUS) that had a meeting, entered their third (and final) decision stage: the cartel report stage. Participants in the cartel report stage, knowing the price choices of the two other firms, simultaneously decided whether they wanted to report their cartel to the authorities.

After all participants made their choice they got feedback on how many members of their group reported their cartel, and their own total earnings in the experiment. The total number of Talers earned by a participant consisted of the market profit, minus fines plus bonuses, where relevant, plus four Talers, if the sum of all this was positive, and was zero Talers otherwise. This 'bankruptcy rule' was introduced in order that the subjects did not leave the lab with negative payments.[7] In addition there was a show-up fee of €1, so that subjects in fact were guaranteed positive earnings. All of this was explained to the participants in the instructions.

Finally participants were privately paid in cash, and the experiment ended.

3.2 Results

We organize this section mainly by responding to the following questions:

- Is there a problem with STANDARD?
- Does LENIENCY improve on STANDARD?
- Is BONUS even better?

[7] Although we could have avoided this rule by using a larger portion of our research budget for the show-up fees, we judged that it was better to let the bulk of that money be used to create salient payoffs in the game itself. The structure of the equilibrium set remains unchanged.

Table 2 Average market prices

	STANDARD	IDEAL
Average market price	96.58	92.25

The suggestive use of the terms "problem", "improve", and "better" in these questions should not be taken as indicative of *our* judgments. Rather, the terms are meant to reflect the viewpoint of *some anti-trust authority*, which wishes to prevent cartel formation and induce competitive pricing.

We will formulate answers on the basis of the market prices,[8] the number of cartels formed, and the proportion of cartels detected. Finally, we close this section by responding to a fourth question:

- *Are there other notable results?*

Under this heading, we report findings that do not accord naturally with the preceding questions.

3.2.1 Is there a problem with STANDARD*?*

To answer this question we compare STANDARD with IDEAL, the market game where cartels cannot be formed. The implicit assumption is that since IDEAL embodies the market conditions that the competition authority would *hope* to have, the outcome under IDEAL provides a natural measuring rod concerning the authority's success in fighting cartels and boosting competitive pricing.

Table 2 gives the average market prices in the two treatments.

The average market price in STANDARD is higher than in IDEAL. A permutation test on the basis of the market price for the individual groups shows that this result is significant (p= 0.00081; one-sided). We conclude that, according to the IDEAL yardstick of success that we attribute to the authority, there is indeed a problem with STANDARD. Markets where cartels can be formed and no fine reduction is issued for whistle-blowing, yield significantly higher prices than markets where cartels cannot be formed.

The question arises whether LENIENCY does any better.

3.2.2 Does LENIENCY *improve on* STANDARD*?*

Table 3 presents all the most important data in our experiment. (A more complete presentation of the disaggregated data appears in Table 5 of Appendix 3.) The table reports the average market price in each treatment, the market prices in each group, and it indicates which groups that engaged in a cartel (shaded background), and which cartels were reported to the authorities (indicated by * markings).

Table 3 shows that LENIENCY gives the second lowest average market price. LENIENCY provides significantly lower market prices than STANDARD ($p = 0.0312$; one-sided permutation test), and there is no significant difference between IDEAL

[8] The market price is the lowest price chosen in the triopoly market.

Table 3 Market prices, cartels, and reports

	STANDARD	LENIENCY	BONUS	IDEAL
Group 1	*100*	*96**	93	92
Group 2	*100*	91	*92**	92
Group 3	92	*95**	*100*	94
Group 4	93	*100**	*96**	91
Group 5	91	*91**	91	91
Group 6	*98**	91	*96**	93
Group 7	*99**	91	93	93
Group 8	91	92	*100**	91
Group 9	*98**	91	*100*	94
Group 10	*100*	*100*	*100**	92
Group 11	*100*	–	*95**	93
Group 12	*97**	93	*92**	91
Group 13		91		
Group 14		92		
Group 15		*100*		
Group 16		*92**		
Average market price	96.58	93.73	95.67	92.25
% of Cartels	67%	50%	75%	–
% of cartels reported	50%	71.4%	77.8%	–

Note: Values in italics indicates that a cartel was formed in the corresponding group. The symbol * indicates that in that group at least one firm reported the cartel. Group 11 in LENIENCY is excluded from the analysis of prices and reports because of a violation of the experimental procedures during the chat

Table 4 Recombinant estimation of Cartel formation

	STANDARD(%)	LENIENCY(%)	BONUS(%)
Recombinant mean	63	46	69
Standard error of the mean	12	11	11

and LENIENCY ($p = 0.10348$; one-sided permutation test). We conclude that LENIENCY reduces market prices relative to STANDARD, approaching the level marked by IDEAL. Hence, the possibility of fine reduction for whistle-blowing has a clear impact on market prices in the intended direction.

So far we have only reported results on pricing, but the competition authority is also interested in the patterns of cartel formation in the market. The authority wants to deter cartels from forming, and to encourage reporting of those cartels which form. LENIENCY does no worse than STANDARD in these respects. In STANDARD 67% of the groups formed a cartel; in LENIENCY the percentage is 50%. However, this difference is not statistically significant ($p = 0.2094$; Fisher exact test, one-sided).

This finding can be further supported by exploring a new statistical technique, known as *recombinant estimation*, developed by Mullin and Reiley (2006). Note that there is no interaction between players prior to their decision whether or not they wish to communicate, and that the actual number of cartels formed is influenced by the realization of the random pairing of participants in the lab. A recombinant estimation computes how many cartels would arise for all possible alternative realizations *that could have occurred*, and uses this information to compute more efficient estimates of mean cartel formation rates than one would get from the

usual mean. In our case the approach is equivalent to having about a 40% improvement over the original number of independent observations. Table 4 reports the recombinant mean percentages of cartels and the associated standard errors for the means (where the figures 12 and 11 should be understood as percentage *points*), by treatment.

Comparing Table 4 with the data reported in Table 3 it is immediate that the picture does not change dramatically, indicating a high degree of consistency in our results. We get slightly smaller percentages of cartel formation, the reason being that in the three treatments there was an instance of a group in which two players did not wish to communicate (Group 4 in STANDARD, Group 9 in LENIENCY, and Group 5 in BONUS; see Table 5 in Appendix 3). Then, when subjected to recombination, these same players cause more cartel formation failures. Contrasting the percentage of cartel formation between STANDARD and LENIENCY we still get that the difference is non-significant ($p = 0.1283$; Fisher exact test, one-sided).[9]

Turning to cartel reporting, since decisions are made after communication and interaction through price decisions, individual decisions are not independent anymore and recombinant estimation is therefore no longer appropriate. Hence, we return to Table 3. We see that 50% of the cartels that took place in STANDARD were reported, while in LENIENCY the percentage increases to 71.4%. A permutation test on the number of individual reports per group gives a significance of 0.092 (one-sided).

All in all, the question 'Does LENIENCY improve on STANDARD?' gets an affirmative answer. LENIENCY provides significantly lower market prices, and there is some tendency towards fewer cartels and more cartel reports.

We next evaluate whether BONUS, the market game where the incentives to report the cartel are the strongest, fares even better.

3.2.3 Is BONUS *even better?*

Table 3 shows that BONUS provides the second highest market price. In fact, there is not a significant difference between BONUS and STANDARD ($p = 0.2872$; one-sided permutation test). On the other hand, IDEAL and LENIENCY exhibit lower prices than BONUS (respectively, $p = 0.0027$ and $p = 0.0920$; one-sided permutation tests). In light of our theoretical analysis one may have been led to expect BONUS to outperform LENIENCY, so against this background our results on BONUS are remarkable.

BONUS gives the highest percentage of cartels formed (75% as opposed to 67% in STANDARD and 50% in LENIENCY), but the differences are not significant. Hypothesis testing on the recombinant data reported in Table 4 shows that there is no significant difference between BONUS and STANDARD, but LENIENCY gives a lower percentage of cartel formation at the 0.10 significance level ($p = 0.0891$; Fisher exact test, one-sided).[10] Finally, BONUS shows the highest percentage of cartels reported (77.8% as opposed to 50% in STANDARD and 71.4% in LENIENCY). However, these differences are not statistically significant.

[9] A t-test on the recombinant data leads to the same conclusion ($p = 0.1401$; t-test, one-sided).

[10] Again, the above is consistent with a t-test analysis: $p = 0.2793$ and 0.063 for STANDARD versus BONUS and LENIENCY versus BONUS, respectively (t-tests, one-sided).

In retrospect, we conjecture that the possibility of entering into a cartel in BONUS with an agreement on high prices is attractive to many players. The possibility of first colluding in prices, then reporting the fellow cartelists and collecting as a bonus all the fines paid by the others is perhaps very tempting. Of course, this would require that such players are not dissuaded by the possibility that other players are as cunning as they are themselves. Players would have to be overly optimistic on the odds of out-smarting the others.

One may imagine that such a phenomenon would go away if our one-shot game were played recurrently, so that players were given an opportunity of learning. If they realize that cartelists are prone to whistle-blowing, then they may also learn not to enter cartels in the first place. The end result could be more competitive pricing. Since we have not considered such treatments, we cannot know but we propose that the matter could be interesting to look at in future research.

3.2.4 Are there other notable results?

In every single instance when a cartel formed and there was no subsequent report, each cartelist chose a price of 100. There is no cartel in the entire experiment with a market price below 100 that was not reported. An examination of the data shows that in all games where at least one player priced below 100 there is some other firm with a price above the market price that reports the cartel. This pattern of play may be suggestive of punishment, and is in line with the equilibrium strategy reported in Example 2 of section 2. Moreover, in all groups of LENIENCY and BONUS that formed a cartel with a subsequent price below 100, the player who chose the market price also reported the existence of the cartel.

In STANDARD, with no monetary incentive to report the existence of the cartel, none of the 4 games with a market price of 100 was reported. In LENIENCY and BONUS, 1 out of 3, and 2 out of 4 respectively were reported. These are so few observations, however, that it not possible to draw very far-reaching conclusions.

Do cartels lead to higher market prices? Our data clearly shows that this is the case. In those treatments where it was possible to enter into a cartel (STANDARD, LENIENCY and BONUS), the average market price in the groups that formed a cartel is 97.4, while the average market price in those groups that did not enter into a cartel is 91.7 which is close to the competitive equilibrium level of 91. The permutation test yields significance at any conventional level.

4 Related literature

Although we have touched on related literature on a few occasions, it may be useful to have a crisp summary all in one place.

There are many experimental studies of price competition, starting with Fouraker and Siegel (1963). See Plott (1989) and Holt (1995) for reviews.[11] Holt's section VIII.D reviews what (relatively little) is known about the impact of communication on collusion; Friedman (1967); Isaac et al. (1984); Holt and Davis (1990), and

[11] More recent studies include Abbink and Brandts (2004, 2005), Bornstein and Gneezy (2002); Brown-Kruse et al. (1994); Cason (1995); Cason and Davis (1995); Cason and Friedman (1997, 2003); Deck and Wilson (2003); Dufwenberg and Gneezy (2000); Dufwenberg et al. (2005); Dugar (2005); Dugar and Sorensen (2005); Fatás et al. (2005); Huck et al. (2000); Mason and Phillips (1997); Morgan et al. (2006), and Selten and Apesteguia (2005).

Brown-Kruse et al. (1990) concern price competition and communication. These studies do not deal with leniency clauses in anti-trust (and differ from our study in other ways, like having repeated interaction), but provide some evidence that communication fosters collusion, a conclusion which accords well with our finding that prices are lowest in IDEAL.[12]

Despite its empirical relevance, not many experimental studies consider anti-trust legislation in any form.[13] As regards leniency law, the only other study we are aware of is Hamaguchi et al. (2005). Their design differs from ours in many respects; in particular, they do not endogenize cartel formation, they have no chat, and they vary the number of cartelists. In their setup, bonus payments as well as higher numbers of cartelists lead to higher rates of cartel dissolution.

Finally, there are theoretical papers by Motta and Polo (2003); Spagnolo (200a,b); Hinloopen (2002), and Aubert et al. (2003) that examine the impact of leniency clauses and bonus systems in anti-trust legislation. Motta and Polo (2003) show that leniency programs may have a perverse effect due to a reduced expected cost of collusion, and conclude that under certain assumptions on the resources of the anti-trust authority leniency programs should not be used. Spagnolo (2000a,b) shows that leniency programs may help sustain high prices because reports could be used as a credible threat to enforce collusion.[14] Furthermore, he considers a bonus system and shows that bonuses may provide a strong enough instrument to fully deter collusion. Our theoretical conclusions in the LENIENCY and BONUS market games are based on the same ideas. Hinloopen (2002) studies the minimal probability of cartel detection that under leniency programs guarantee the avoidance of cartel formation. Aubert et al. (2003) study the influence of leniency and bonus programs on intra-firm organizational issues such as turn-over rates and agency problems between owners and employees. They show that a bonus system for employees may strongly decrease the benefits of collusion. See Rey (2003) for a general discussion of the theory of competition policy, of which these studies are part.[15] In future research, it may be of interest to test these theories experimentally, and investigate whether our findings extend to the settings described.

5 Summing up

The aim of this paper is to experimentally examine how leniency programs in anti-trust influence pricing and the formation and detection of cartels. The idea on which

[12] Some work (in psychology as well as in economics) examines how communication affects strategic interaction, experimentally and theoretically, in other types of (coordination, bargaining, or trust) games. See Charness and Dufwenberg (2005) for a discussion.

[13] Hong and Plott (1982) investigate the influence of a rate filling policy to shippers on US inland water routes. Grether and Plott (1984) examine different pricing practices motivated by a specific litigation of the US Federal Trade Commission. Davis and Wilson (2005) experimentally evaluate the Antitrust Logit Model developed by the US Department of Justice to identify anticompetitive practices arising from horizontal mergers. Other experimental studies dealing with anticompetitive practices and mergers include Davis and Wilson (2000) and Lindqvist and Stennek (2005). Davis and Wilson (2002) study collusion in experimental procurement auctions.

[14] For related results, see also Buccirossi and Spagnolo (2001) and Ellis and Wilson (2003).

[15] See also McCutcheon's (1997) theoretical evaluation of *the Sherman act*. The paper is not about leniency law, but it is still related in that it concerns the impact of communication on collusion.

leniency legislation is based is crisply summarized by the following quotation from the OECD Competition Committee (2002) report (emphasis in original):

> *The challenge in attacking hard-core cartels is to penetrate their cloak of secrecy. To encourage a member of a cartel to confess and implicate its co-conspirators with first-hand, direct "insider" evidence about their clandestine meetings and communications, an enforcement agency may promise a smaller fine, shorter sentence, less restrictive order, or complete amnesty.*

We investigate the impact of leniency clauses using four market games, which differ with respect to the anti-trust legislation embodied. In the game STANDARD all cartelists are liable to penalty. In LENIENCY andBONUS, first whistle-blowers are granted immunity from fines, and inBONUS they may even collect bonuses. The conditions of LENIENCY resemble those applied in the OECD, and we consider BONUS because our theoretical analysis suggests that an anti-trust authority might prefer the outcome. In IDEAL, finally, cartel formation is outright impossible, a condition which would seem bliss from the viewpoint of the anti-trust authority, and which thus provides a yard-stick for measuring the success of the other anti-trust legislations.

A theoretical analysis suggests that STANDARD may induce cartel formation that sustains maximum prices at equilibrium. The same goes for LENIENCY, although the theoretical support appears less strong from an ex ante point of view. It takes BONUS to theoretically thwart cartels and induce competitive pricing.

It is natural to wonder how these conclusions stand up empirically, which is where our experiment comes into the picture. In the lab, LENIENCY displays significantly lower prices than STANDARD which actually gives the highest market prices of all treatments. The lowest prices are found in IDEAL, and there is no significant difference between LENIENCY and IDEAL. LENIENCY furthermore gives the lowest percentage of cartel formation.

Market prices in BONUS are above those of IDEAL and LENIENCY, and not statistically different to those observed in STANDARD. Moreover, the highest number of cartels are found in BONUS. Against the backdrop of the theoretical predictions, the findings regarding BONUS appear quite surprising. The theoretical analysis suggested that BONUS might have the most success in pre-empting cartels and inducing competitive pricing. That is clearly not the case.

We limit attention to these four market games, which constitute modifications from a simple benchmark version of the one-shot Bertrand model. Treating a basic model seems to us a natural starting point for experiments on leniency clauses in anti-trust, and it is our hope that future research may consider extensions to judge how 'robust' our findings are. Important issues to consider include repetition, asymmetries between firms, cartel formation involving a subset of firms, random cartel detection, variations regarding how fines are levied, and markets with heterogeneous goods.[16] For all of these reasons, the external validity of our results may legitimately be called to question, so whatever policy conclusions we draw must

[16] We note two things, about the first and the last of these issues: (i) It is a non-trivial problem in experimental design how to operationalize leniency clauses with repeated price competition. For example, it is not obvious what fines should be imposed in round z if someone blows the whistle in round y after there was chatting in round x, say with $x<y<z$. (ii) In our view, relaxing the assumption of homogeneity of goods is the most promising issue. In our design, firms that do not choose the lowest price have zero revenue and may in effect costlessly blow the whistle on

surely be taken with a grain of salt. We, tentatively, venture the following: Our findings in this paper provide no reason for Gary Spratling and Mario Monti to feel disappointed with the leniency clauses that have recently been incorporated into the anti-trust legislation in most member states of the OECD.

Appendix 1: The instructions

A.1.1 *Instructions for* STANDARD

Introduction Welcome to this experiment which concerns decision making in a market. You will be matched in groups of three persons. You will not be told who the other two persons in your group are. Each group of three persons is independent from the others.

We use Talers to reward you. Each Taler is worth 2 Euros. How many Talers you win depends on the decisions made by you and the two others in your group. At the end of the experiment, all your Talers will be converted to Euros and paid to you in cash.

In addition, you will be paid a 1 Euro show up fee.

Instruction In this market, you and the two others compete in prices. It is possible to form a cartel, that is, to have a meeting where you could discuss prices. In reality, cartels are often illegal and if someone reports a cartel to the government the cartel members may be penalized. In this experiment there is a similar opportunity to report a meeting. If you have a meeting, and if someone reports this, you may have to pay a fine.

The experiment is composed of three phases.

Phase 1: The meeting Each person in your group must decide whether he/she wants to have a meeting with the two others. If there is at least one person who does not want to have a meeting, then there will be no meeting, and Phase 2 will start. If all three persons decide that they want to have a meeting, then a chat will be started on your computer screens. You will then be able to chat with the other two persons in your group for 10 min. You may write whatever you want, except that you may not identify yourself by name or number or gender or appearance or in any other way. (The experimenter will monitor the chat; violations will result in disqualification from all payments and further participation in the experiment.) After the chat has finished, Phase 2 will start.

Phase 2: The prices Each person in your group must choose one of the following *prices*:

91, 92, 93, 94, 95, 96, 97, 98, 99, 100

Those persons who choose the lowest price in their group are called *low price sellers*. The others are called *high price sellers*. The profit (in Talers) of a low price seller is the difference between his/her price and 90, divided by the number of low price sellers. The profit of a high price seller is zero.

their competitors despite the absence of immunity clauses. With heterogeneous products, firms that do not choose the lowest price would have non-zero revenue and therefore whistle-blowing would not be gratis.

Phase 3: The reports In this phase you first get information about the price choices for all persons in your group, and your earnings in Phase 2. What comes next depends on whether or not you had a meeting in Phase 1, and if someone in your group *reports* this. If you did not have a meeting in Phase 1, then the experiment ends here.

If you had a meeting in Phase 1, then each of you must decide whether or not to report this. If none of you chooses to report the meeting, then the experiment ends here.

If you had a meeting in Phase 1, and if at least one of you report this, then certain *fines* will have to be paid. In order to explain how this is done, we must define what is meant by a persons *revenue*: The revenue of a low price seller is his price, divided by the number of low price sellers. The revenue of a high price seller is zero. Each person's fine will be determined as 10% of that person's revenue.

Payment You will be paid as described above (market profit minus the fine) plus 4 Talers, if this sums to a positive number. In addition you will receive the show-up fee. If the market profit minus the fine plus the 4 Talers does not sum to positive number, you will receive only the show-up fee.

Thank you for your participation!

A.1.2 *Instructions for* LENIENCY

Introduction Welcome to this experiment which concerns decision making in a market. You will be matched in groups of three persons. You will not be told who the other two persons in your group are. Each group of three persons is independent from the others.

We use Talers to reward you. Each Taler is worth 2 Euros. How many Talers you win depends on the decisions made by you and the two others in your group. At the end of the experiment, all your Talers will be converted to Euros and paid to you in cash.

In addition, you will be paid a 1 Euro show up fee.

Instruction In this market, you and the two others compete in prices. It is possible to form a cartel, that is, to have a meeting where you could discuss prices. In reality, cartels are often illegal and if someone reports a cartel to the government the cartel members may be penalized. In this experiment there is a similar opportunity to report a meeting. If you have a meeting, and if someone reports this, you may have to pay a fine.

The experiment is composed of three phases.

Phase 1: The meeting Each person in your group must decide whether he/she wants to have a meeting with the two others. If there is at least one person who does not want to have a meeting, then there will be no meeting, and Phase 2 will start. If all three persons decide that they want to have a meeting, then a chat will be started on your computer screens. You will then be able to chat with the other two persons in your group for 10 min. You may write whatever you want, except that you may not identify yourself by name or number or gender or appearance or

in any other way. (The experimenter will monitor the chat; violations will result in disqualification from all payments and further participation in the experiment.) After the chat has finished, Phase 2 will start.

Phase 2: The prices Each person in your group must choose one of the following *prices*:

91, 92, 93, 94, 95, 96, 97, 98, 99, 100

Those persons who choose the lowest price in their group are called *low price sellers*. The others are called *high price sellers*. The profit (in Talers) of a low price seller is the difference between his/her price and 90, divided by the number of low price sellers. The profit of a high price seller is zero.

Phase 3: The reports In this phase you first get information about the price choices for all persons in your group, and your earnings in Phase 2. What comes next depends on whether or not you had a meeting in Phase 1, and if someone in your group *reports* this. If you did not have a meeting in Phase 1, then the experiment ends here.

If you had a meeting in Phase 1, then each of you must decide whether or not to report this. If none of you chooses to report the meeting, then the experiment ends here.

If you had a meeting in Phase 1, and if at least one of you report this, then certain *fines* will have to be paid. In order to explain how this is done, we must define what is meant by a persons *revenue*: The revenue of a low price seller is his price, divided by the number of low price sellers. The revenue of a high price seller is zero.

The following four cases explain how the fine is determined.

If you report the meeting and neither of the other two reports the meeting, then you pay no fine.

If you report the meeting and exactly one of the other two also reports the meeting, then your fine is 5% of your revenue.

If you report the meeting and both the other two also report the meeting, then your fine is 6.67% of your revenue.

If you do not report the meeting (but someone else does), then your fine is 10% of your revenue.

Payment You will be paid as described above (market profit minus the fine) plus 4 Talers, if this sums to a positive number. In addition you will receive the show-up fee. If the market profit minus the fine plus the 4 Talers does not sum to positive number, you will receive only the show-up fee.

Thank you for your participation!

A.1.3 *Instructions for* BONUS

Introduction Welcome to this experiment which concerns decision making in a market. You will be matched in groups of three persons. You will not be told who the other two persons in your group are. Each group of three persons is independent from the others.

We use Talers to reward you. Each Taler is worth 2 Euros. How many Talers you win depends on the decisions made by you and the two others in your group. At the end of the experiment, all your Talers will be converted to Euros and paid to you in cash.

In addition, you will be paid a 1 Euro show up fee.

Instruction In this market, you and the two others compete in prices. It is possible to form a cartel, that is, to have a meeting where you could discuss prices. In reality, cartels are often illegal and if someone reports a cartel to the government the cartel members may be penalized. In this experiment there is a similar opportunity to report a meeting. If you have a meeting, and if someone reports this, you may have to pay a fine. It is also possible that you receive a bonus if you report the meeting.

The experiment is composed of three phases.

Phase 1: The meeting Each person in your group must decide whether he/she wants to have a meeting with the two others. If there is at least one person who does not want to have a meeting, then there will be no meeting, and Phase 2 will start. If all three persons decide that they want to have a meeting, then a chat will be started on your computer screens. You will then be able to chat with the other two persons in your group for 10 min. You may write whatever you want, except that you may not identify yourself by name or number or gender or appearance or in any other way. (The experimenter will monitor the chat; violations will result in disqualification from all payments and further participation in the experiment.) After the chat has finished, Phase 2 will start.

Phase 2: The prices Each person in your group must choose one of the following *prices*:

91, 92, 93, 94, 95, 96, 97, 98, 99, 100

Those persons who choose the lowest price in their group are called *low price sellers*. The others are called *high price sellers*. The profit (in Talers) of a low price seller is the difference between his/her price and 90, divided by the number of low price sellers. The profit of a high price seller is zero.

Phase 3: The reports In this phase you first get information about the price choices for all persons in your group, and your earnings in Phase 2. What comes next depends on whether or not you had a meeting in Phase 1, and if someone in your group *reports* this. If you did not have a meeting in Phase 1, then the experiment ends here.

If you had a meeting in Phase 1, then each of you must decide whether or not to report this. If none of you chooses to report the meeting, then the experiment ends here.

If you had a meeting in Phase 1, and if at least one of you report this, then certain *fines* will have to be paid, and certain *bonuses* paid out. In order to explain how this is done, we must define what is meant by a persons *revenue*: The revenue of a low price seller is his price, divided by the number of low price sellers. The revenue of a high price seller is zero.

The following four cases explain how the fine and bonus is determined.

If you report the meeting and neither of the other two reports the meeting, then you pay no fine. You receive a bonus equal to the fine paid by the other two.

If you report the meeting and exactly one of the other two also reports the meeting, then your fine is 5% of your revenue. You receive a bonus equal to half of the fine paid by the person who did not report the meeting.

If you report the meeting and both the other two also report the meeting, then your fine is 6.67% of your revenue. You receive no bonus.

If you do not report the meeting (but someone else does), then your fine is 10% of your revenue. You receive no bonus.

Payment You will be paid as described above (market profit minus the fine plus the bonus) plus 4 Talers, if this sums to a positive number. In addition you will receive the show-up fee. If the market profit minus the fine plus the bonus plus the 4 Talers does not sum to positive number, you will receive only the show-up fee.

Thank you for your participation!

A.1.4 Instructions for IDEAL

Introduction Welcome to this experiment which concerns decision making in a market. You will be matched in groups of three persons. You will not be told who the other two persons in your group are. Each group of three persons is independent from the others.

We use Talers to reward you. Each Taler is worth 2 Euros. How many Talers you win depends on the decisions made by you and the two others in your group. At the end of the experiment, all your Talers will be converted to Euros and paid to you in cash.

In addition, you will be paid a 1 Euro show up fee.

Instruction In this market, you and the two others compete in prices.

The prices Each person in your group must choose one of the following *prices*:

91, 92, 93, 94, 95, 96, 97, 98, 99, 100

Those persons who choose the lowest price in their group are called *low price sellers*. The others are called *high price sellers*. The profit (in Talers) of a low price seller is the difference between his/her price and 90, divided by the number of low price sellers. The profit of a high price seller is zero.

Payment You will be paid as described above (market profit) plus 4 Talers. In addition you will receive the show-up fee.

Thank you for your participation!

Appendix 2: The questionnaire

Below is the questionnaire for BONUS. *The questionnaires for the other treatments include subsets of these questions, omitting those that were not relevant in the specific treatment.*

1) How many participants form a group?			
1	2	3	4
2) How many participants in your group must indicate that they want to communicate with the others if a chat is to be started?			
0	1	2	3
3) If your price is p and you are the only "low price seller" what are your profits?			
0	p	(p-90)	(p-90)/2
4) and your revenues?			
0	p	p/2	(p-90)/2
5) If your price is p and you are one of two "low price sellers" what are your profits?			
0	p/2	(p-90)	(p-90)/2
6) and your revenues?			
0	p-45	p	p/2
7) If your price is p and the price of the other two are also p what are your profits?			
0	p/3	(p-90)	(p-90)/3
8) and your revenues?			
0	p	(p-90)/3	p/3
9) If your price is p and you are a "high price seller" what are your profits?			
0	(p-90)	P	(p-90)/3
10) and your revenues?			
0	p	p-90	p/3
11) If you are a "high price seller" and you are imposed a fine of 10%, how much do you have to pay?			
0	10	(90-p)/10	p/10
12) If there was a meeting in your group, and nobody reports it, is it then possible that some one in your group must pay a fine?			
Yes	No		
13) If there was a meeting in your group, and you are the only one reporting it, what are the fines to you?			
None	10% of your revenues	5% of your revenues	3.33% of your revenues
14) and what bonus will you receive?			
None	10	The fine paid by the others	Half of the fine paid by the participant in your group who did not report the meeting
15) If there was a meeting in your group, and you and another participant report it, what are the fines to you?			
None	10% of your revenues	5% of your revenues	3.33% of your revenues
16) and what bonus will you receive?			
None	10	The fine paid by the others	Half of the fine paid by the participant in your group who did not report the meeting
17) If there was a meeting in your group, and if all three report it, what are the fines to you?			
None	10% of your revenues	5% of your revenues	3.33% of your revenues
18) If there was a meeting in your group, and somebody else but not you reports it, what are the fines to you?			
None	10% of your revenues	5% of your revenues	3.33% of your revenues
19) and what bonus will you receive?			
None	10	The fine paid by the others	Half of the fine paid by the participant in your group who did not report the meeting

Appendix 3

Table 5 Individual prices, cartels, and individual reports

	STANDARD			LENIENCY			BONUS			IDEAL		
	Firm 1	Firm 2	Firm 3	Firm 1	Firm 2	Firm 3	Firm 1	Firm 2	Firm 3	Firm 1	Firm 2	Firm 3
Group 1	*100*	*100*	*100*	*100**	*96**	*100**	**93**	95	**95**	94	93	92
Group 2	*100*	*100*	*100*	**95**	**91**	95	*92*	*92**	*92**	92	94	97
Group 3	**93**	92	**93**	*98**	*95**	*100*	*100*	*100*	*100*	96	99	94
Group 4	**93**	95	95	*100*	*100*	*100**	*96**	*100*	*100**	91	95	93
Group 5	**93**	**91**	92	*91**	*100**	*97**	91	93	**92**	93	91	91
Group 6	*98*	*100*	*100**	**91**	93	**93**	*96*	*96**	*96**	94	93	93
Group 7	*100**	*99*	*99**	**96**	92	**91**	**97**	**93**	93	99	99	93
Group 8	**91**	**93**	91	**92**	94	94	*100*	*100**	*100*	91	92	100
Group 9	*100**	*100**	*98*	91	91	**92**	*100*	*100*	*100*	94	96	99
Group 10	*100*	*100*	*100*	*100*	*100*	*100*	*100**	*100*	*100*	92	100	95
Group 11	*100*	*100*	*100*	–	–	–	*95**	*100**	*100*	93	95	94
Group 12	*97*	*98*	*100**	93	**95**	**93**	*98*	*92**	*96**	100	100	91
Group 13				**91**	91	**91**						
Group 14				92	**93**	**95**						
Group 15				*100*	*100*	*100*						
Group 16				*99**	*92**	*100**						

*Note:*A bold price indicates that the firm wanted to communicate with the others. Values in italics indicates that a cartel was formed in the corresponding group. The symbol * indicates that the firm reported the cartel. Group 11 in LENIENCY is excluded from the analysis of prices and reports because of a violation of the experimental procedures during the chat

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