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, theoretically and experimentally.

Keywords: Anti-trust, leniency, immunity, amnesty, blow the whistle, cartels, price competition, Bertrand model, experiment, communication

JEL codes: 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, and Scherer & Ross 1990). Many other countries enacted similar laws in the 20th 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):

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[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.

> [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 Gary 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, it is not obvious 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 two ways. *First*, we theoretically analyse a few stylized market games which highlight and isolate the key feature of some anti-trust policy. We derive game-theoretic predictions, which are contrasted to the views of the world held by competition authorities. *Second*, we examine our market games experimentally. We test whether the theoretical predictions stand up, and whether the effects envisioned by anti-trust authorities obtain.

When evaluating experiments in industrial organization one should critically examine the parallel between the laboratory and naturally occurring markets. To what extent can the behavior of *students* in a lab reveal something about the conduct of *firms* in the marketplace? Arguably, this parallel is strengthened by our focus on communication, in cartels that must rely on trust to enforce agreements. The communication occurs between *persons*, in the lab and in other markets alike.

Theory, experimental material (procedures, hypotheses, results), connections to related literature, and conclusions appear in sections 2, 3, 4, and 5, respectively.

2. THEORY

The nature and complexity of naturally occurring markets varies. Which particular characteristics should be addressed in an experiment? We believe that 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 build on a version of the classic Bertrand model of price competition, leaving aside more complicated extensions of that model (involving, say, heterogeneous goods, incomplete information, or repeated interaction).[2] Our goal is to provide benchmark results, which may serve as a backdrop to and reference point for future research that

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

examines enriched contexts and extends, generalizes, and tests the robustness of our findings.

Textbook versions of the Bertrand model often admit infinitely many strategies, but we consider a discretized version similar to that introduced by Dufwenberg & 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}.
- 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.

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*. 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 abstract from 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. There are three stages. 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, …, 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 ten percent of its revenue.[3] This *ten percent rule* is directly adopted from the current legislation of the European Union (European Commission 2002b).

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 if it helps them achieve higher prices, and if their cartel is not subsequently detected. The firms never profit from being in a detected cartel; the ten percent 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 the cartel.

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

[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.

equilibria involve successful collusion. The following example describes an equilibrium resulting in collusion at the highest possible price.

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 deviate, undercutting the others with a price of 99, its payoff (given that the others stay with their equilibrium strategies) would be -.9, which is strictly less than 10/3, the payoff from sticking to the equilibrium strategy.

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

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 ten percent of its revenue. If two firms report the cartel, then each of these firms pay a fine of five percent of its revenue, while the third firm pays ten percent of its revenue. If all three firms reports the cartel, then each firm pays a fine of 6.67 percent 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 are roughly consistent with partial immunity clauses that often apply if more than one cartelist file reports.

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

BONUS

Given our theoretical finding that LENIENCY is not unambiguously successful in avoiding cartels and inducing competitive behavior, it is natural to think of alternative schemes which theory would suggest achieve that end. 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.

To see that collusion is ruled out, note first that the strategy profile described in Example 2 is *not* an equilibrium in BONUS (unlike in STANDARD or in LENIENCY): In the subgame after each cartelist has indicated that it wishes to enter a cartel, to choose a price of 100 is no longer part of a best response. By undercutting to, say, 99 and following up by whistle-blowing, the firm would get a payoff of 2.46, which is higher than the payoff of 1.13 resulting from the strategy profile described in Example 2.

Analogous arguments show that strategy profiles involving collusion at symmetric price vectors of 99 and 98 can not be equilibria. The remaining symmetric price distributions in cartels can not be equilibria either, but to show this requires a different argument. Consider, for example, the subgame where the triopoly forms a cartel, each firm choose a price of 97, and each firm reports the cartel. This gives a payoff to each firm of 0.19. One may verify that individual undercutting, say to 96, now actually gives a lower payoff, so such a deviation is not in a firm's interest in the subgame following the meeting. However, in this case the best-response to the strategy profile under consideration involves not joining the cartel in the first place, and choosing a price of 91. This assures a payoff of at least (91-90)/3=1/3>0.19.

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

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 path of play described is not the result of an equilibrium strategy profile (*e.g.*, either player can gain by choosing 94).

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 theoretical conclusion: IDEAL *induces competitive pricing.*

Overview

Table 1 gives an overview of our four market games, highlighting some key features:

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)

3. THE EXPERIMENT

3.1 Procedures

The experiments were run at the Laboratory for Experimental Economics at the University of Bonn in July 2002. The computerised program was developed using RatImage (Abbink & Sadrieh 1995). We had 12 groups of 3 participants in each of the four treatments, except in LENIENCY where we had 16 groups of three participants. 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.[4] Average earnings in the experiment were €11, and the maximum and minimum payment made were €29 and €1 respectively. 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 minutes 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 A) 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 Appendix B) 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.

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

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 to 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 earnings of a participant consisted of the market profit, minus fines plus bonuses, where relevant, plus four Talers, if the sum of all this was positive. This rule was introduced in order to ensure that the subjects do not leave the lab with a loss. In addition there was a show-up fee of €1, so that subjects in fact were guaranteed positive earnings. Note that if market profit minus fines plus bonuses plus four Talers did not sum to a positive number, a participant received only the show-up fee. 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?*

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,[5] 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?*

Here we report findings that do not accord naturally with the preceding questions.

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.

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

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

Table 2: Average market prices

	STANDARD	IDEAL
Average Market Price	96.58	92.25

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 = .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.

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 Appendix C.) 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: 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: A shaded cell 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 3 shows that Leniency gives the second lowest average market price. Leniency provides significantly lower market prices than Standard (p = .0312; one-sided permutation test), and there is no significant difference between Ideal and Leniency (p = .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 = .2094; Fisher exact test, one-sided).

Concerning the number of cartels reported, Table 2 shows 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 .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.

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 = .2872; one-sided permutation test). On the other hand, IDEAL and LENIENCY exhibit lower prices than BONUS (respectively, p = .0027 and p = .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), and 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.

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 rather optimistic on the odds of out-smarting the others.

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 level.

4. RELATED LITERATURE

There are many experimental studies of price competition, starting with Fouraker & Siegel (1963). See Plott (1989) and Holt (1995) for reviews.[6] Holt's section VIII.D reviews what (relatively little) is known about the impact of communication on collusion; Friedman (1967), Isaac, Ramey & Williams (1984), Holt & Davis (1990), and Brown-Kruse, Cronshaw & Shenk (1990) concern price competition and communication. These studies do not deal with leniency clauses in anti-trust (and the set-up typically differs from ours 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.[7]

Despite of its empirical relevance, few experimental studies actually consider anti-trust legislation in any form. Hong & Plott (1982) investigate the influence of a rate filling policy to shippers on US inland water routes, while Grether & Plott (1984) examine different pricing practices motivated by a specific litigation of the US Federal Trade Commission. These studies show that the success of anti-trust

[6] More recent studies include Brown-Kruse, Rassenti, Reynolds & Smith (1994), Cason (1995), Cason & Davis (1995), Cason & Friedman (1997), Mason & Phillips (1997), Dufwenberg & Gneezy (2000), Huck, Normann & Oechssler (2000), Morgan, Orzen & Sefton (2001), Abbink & Brandts (2002), Bornstein & Gneezy (2002), Dufwenberg, Gneezy, Goeree & Nagel (2002), and Selten & Apesteguia (2002).

[7] 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 & Dufwenberg (2003, footnote 4) for references.

regulations may depend on surprising behavioral regularities, which highlights the importance of laboratory studies on understanding anti-trust.

Finally, there are theoretical papers by Motta & Polo (2002), Spagnolo (2000a, 2000b), and Hinloepen (2002) that examine the impact of leniency clauses in anti-trust legislation. See Rey (2001) for a general discussion of the theory of competition policy, of which these studies are part.[8] The games dealt with are neither more nor less special than ours (there are many differences concerning the nature of fines, whether there is repetition, et cetera), and the theories proposed illustrate that whether leniency fosters or hinders collusion may depend on a variety of issues in subtle ways.[9] For future research, it may be of interest to test these theories experimentally, and to investigate whether our findings extend to those settings.

5. SUMMING UP

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

[8] See also McCutcheon's (1997) theoretical evaluation of *the Sherman act*. That paper is not about leniency clauses, but it is related to ours in that central ideas concern the impact of communication on collusion.

[9] For example, Spagnolo (2000b) examines the impact of imposing a *fixed fine* on firms caught colluding. The unique subgame perfect equilibrium of his model without leniency clauses entails marginal cost pricing, in contrast to our analysis of STANDARD where fines dependend on revenue (the EU 10% rule) and where every symmetric price distribution is a subgame perfect equilibrium.

To learn about the impact of leniency policy based on observation of market data is hard, because undetected cartels cannot be observed and because one cannot observe how a market would have operated with some other anti-trust policy. The experimental laboratory may then be useful, as a "wind tunnel" for revealing insights about naturally occurring markets. The wind tunnel analogy (to laboratory tests of prototypes for aircraft) was mentioned by the Nobel committee, which awarded the 2002 economics prize to Vernon Smith partly because he pioneered the associated research strategy (see Royal Swedish Academy of Sciences, 2002, section 1.3).

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 and BONUS, first whistle-blowers are granted immunity from fines, and in BONUS 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.

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 future research may consider extensions to judge how "robust" our findings are.[10]

[10] Important issues to consider include repetition, asymmetries between firms, cartel formation involving a subset of firms, random cartel detection, and markets with heterogeneous goods. The last of these may seem especially critical. In our design, firms that do not choose the lowest price have zero revenue and may in effect costlessly blow the whistle on 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.

Our game theoretic 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 our theoretical analysis the findings regarding BONUS appear quite surprising. Our theoretical analysis suggested that BONUS might have the most success in pre-empting cartels and inducing competitive pricing. That is clearly not the case.

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 A: THE INSTRUCTIONS

A.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 minutes. 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. 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.2 *Instructions for* LENIENCY

INTRODUCTION
{*Exact same text as in* STANDARD}

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 minutes. 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.3 *Instructions for* BONUS

INTRODUCTION
{*Exact same text as in* STANDARD}

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 minutes. 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.4 *Instructions for* IDEAL

INTRODUCTION
{*Exact same text as in* STANDARD}

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 B: 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 C: DATA

Table 4: 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. A shaded cell 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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