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Laboratory evidence on the effectiveness of corporate leniency programs

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and

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The number of cartels detected in the United States and in Europe has increased considerably since the introduction of corporate leniency programs in antitrust legislation. It cannot, however, be ruled out that this apparent success results in part from increased cartel activity. We explore the effects of corporate leniency programs on pricing and cartel activity by use of an experiment. We find that in the lab (i) fewer cartels are established when a leniency program is in place, and (ii) cartels that do exist are less successful in charging prices above the static Nash equilibrium price and have lower survival rates.

1. Introduction

■ Corporate leniency programs have become an increasingly important tool for antitrust authorities to break cartels. These programs provide fine reductions and/or rewards for reporting a cartel to antitrust authorities by one of the cartel members. The first such program was initiated by the U.S. Department of Justice in 1978. Since then, they have become part of antitrust legislation in the United States, the European Union, and other countries (OECD, 2002; Spagnolo, forthcoming).

The number of cartels detected has increased considerably since the introduction of leniency programs, but “in principle this could even be due to an increase in cartel activity” (Spagnolo, 2004). The reason for this is that along with the enhanced incentive to cheat on a cartel while simultaneously reporting it, leniency programs can also make cartel activity less costly for

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participants. This occurs when cartel profits net of reduced fine payments exceed both defection and expected cartel profits. When this happens, too many cartel members are given excessive fine reductions upon reporting, and cartels are formed and reported continuously. Leniency programs with this feature are called exploitable (Spagnolo, 2004). So it remains an open question whether the dramatic increase in leniency applications is proof of their success in fighting cartels or merely reflects increased cartel activity due to their conditions having become too generous.

To answer this question, empirical evidence on the effects of leniency programs would be most welcome. This type of evidence, however, is hard to come by because information on cartels not yet disclosed is typically not available. Moreover, natural experiments do not easily present themselves, as it is not feasible to adjust legislation too often.¹ With a laboratory experiment, however, one can study the effects of leniency programs on the willingness of subjects to engage in (nonbinding) price discussions and on the market prices that result.

Here we report on four treatments of an experiment that implements such a setup and that follow up and extend the work of Apesteguia et al. (2007). In each treatment, subjects repeatedly play a discrete homogeneous-goods Bertrand pricing game in groups of three. This game has been introduced by Dufwenberg and Gneezy (2000). In each period, subjects have to choose an integer in the range 101–110. Subjects who choose the lowest number (price) p receive net earnings of $(p - 100)/L$, with L equal to the number of subjects choosing the lowest number. This lowest number is labeled the market price. Any price above the market price yields no revenue. The Nash equilibrium price of the one-shot game is $p^N = 101$. The treatments differ in the options of subjects to have nonbinding price discussions prior to a market phase in which the actual price is determined. In comparing behavior and market outcomes across treatments, we study the effects of corporate leniency programs on pricing, cartel activity, and cartel stability.

One notion of cartel activity considers all situations where noncompetitive prices ($p > 101$) occur as collusive. This notion is consistent with models of tacit collusion with homogeneous products. Apesteguia et al. (2007) apply a different notion by defining a cartel as the situation when all group members unanimously decide to discuss prices. This latter notion is more in line with current legal practice that firms are unlikely to be found guilty of collusion when there have not been explicit attempts by the firms involved to communicate with each other (Motta, 2004). In our analysis, we consider both notions of cartel stability. Our evidence shows a positive relationship between having price discussions and the occurrence of noncompetitive prices, and for this reason qualitative outcomes are similar, whichever notion is adopted.

The remainder of our article proceeds as follows. Section 2 provides a brief overview of previous studies and an outline of our experimental design. Section 3 discusses the results and Section 4 concludes.

2. Literature and experimental design

■ Apesteguia et al. (2007) examine the effects of leniency programs in a one-shot Bertrand game. In a one-shot game, the positive effects of leniency programs are likely to be overstated, though, because a negative backlash of whistle-blowing for future cooperation is ruled out. Our design, which has subjects repeatedly play the same stage game with the same opponents, reduces this bias. In this article, we do not, however, attempt to model the dynamic strategies that may ensue from this setup.

In Apesteguia et al. (2007), the fine reduction is split among all cartel members who report. In contrast, we explicitly take into account the order in which cartel members apply for leniency. In this way, we open up the possibility for subjects to “race to report” by giving early applicants larger fine reductions. Another difference from their setup is that our communication phase is shorter and more structured, in that subjects can only communicate about prices and only for one

¹ One possibility would be to compare cartel behavior across jurisdictions with different types of corporate leniency programs enacted. Yet, additional factors that affect individual firm behavior are likely to differ between jurisdictions, including the institutional environment, the ruling legal system, and cultural norms.

minute rather than ten minutes. In practice, cartel members can talk about anything for as long as they want. In this respect, the approach of Apesteguia et al. (2007) comes closer to reality.² Our results should therefore be treated as complementary to those of Apesteguia et al. (2007).

Leniency programs differ in the size of fine reduction for reporting a cartel, in the extent to which leniency is still an option if the antitrust authorities have started an investigation into the particular cartel before a member reports it, whether it is public information which and how many firms have applied for leniency, and whether fine reductions are available for reporting cartel members who are not the first to report the cartel. For example, in The Netherlands, complete exemption from fine payments is available to cartel members who are the first to report a cartel, that fully cooperate with the ensuing investigation, that are not the cartel's ringleader, and provided that no investigation into the particular cartel is ongoing. In case the antitrust authorities are already investigating the particular cartel, the fine reduction is reduced by 0–40 percentage points. For later reporting, cartel member fine reductions in the range of 10–40% are available. As a rule, information as to which firms applied for leniency is not made public during the investigation. The leniency program we investigate resembles the current practice in many jurisdictions: the first applicant receives full amnesty, the second is given a 50% fine reduction, the third to come forward has to pay the full fine, and applicants remain anonymous.³ As the experiment is motivated in part by practice, we consider a moderate program only as opposed to a courageous program. In the latter, the first applicant receives a monetary reward in addition to immunity.

Theory offers a number of predictions we can test with our design. First, given that the leniency program we consider is nonexploitable, we expect introduction of the program to lead to a reduction of the number of cartels formed (Motta and Polo, 2003). Second, we expect the leniency program to lead to lower average prices, as cartel activity is generally associated with higher price levels. Third, with regard to the cartels that do form despite the leniency program, Spagnolo (2004) points out that leniency programs provide cartel members who defect from the collusive agreement, that is, who charge a lower price than the agreed-upon price, a *protection-from-fines* motive as long as the expected reduced fines of the leniency program are below the expected fine of a defecting agent who does not report. Because of this effect, we expect to observe that defecting cartel members always apply for leniency in the period of defection.

□ **Experimental design.** We implement four treatments. Benchmark is the standard game where subjects cannot discuss prices. Communication adds the possibility for subjects to discuss prices, at no cost (see Step 1 below). If group members unanimously agree to discuss prices, a communication screen opens: a cartel is established. In Antitrust, groups that discuss price face in each period a probability of 15% of being detected by an antitrust authority.⁴ Upon detection, group members have to pay a fine equal to 10% of their revenue in that period. Leniency resembles Antitrust, except that subjects who participate in a cartel have the possibility to report the cartel in exchange for a fine reduction (see Step 3 below). In the experiment, the fine liability of individual cartel members automatically carries over to the next period unless the cartel breaks down due to detection or a leniency application by one or more cartel members. This is analogous to an infinite repose period.

Step 1. Communication phase. Each subject has to decide whether she wants to discuss prices or not by pressing the appropriate button; a communication window opens only if all three group members simultaneously choose to discuss price. The experiment thus precludes the creation

² Restricting the communication to price discussions precludes subjects bringing the outside world into the experiment ("If I win I will buy you a beer").

³ Unlike, for example, Motta and Polo (2003), we do not distinguish between the situation where the antitrust authorities have started an investigation or not.

⁴ Strictly speaking, having a discussion about prices is not illegal. To label the third treatment Antitrust emphasizes, however, the introduction of fines. The chosen probability reflects the empirical finding by Bryant and Eckard (1991) that in a given year, 13%–17% of the existing price-fixing cartels are detected.

of partial cartels. Subjects only learn the joint communication decision in their group, not the individual willingness to communicate or the possible cartel activity in other groups.

If a cartel is established, a communication window opens that allows each cartel member to indicate his or her acceptable price range. All group members simultaneously supply a minimum and maximum price from the choice set $\{101, 102, \dots, 110\}$. If a subject insists on one particular price, she can articulate this by choosing that price both as her minimum and maximum price. The intersection of all three price ranges becomes the choice set of a second round of price negotiations. If the intersection is empty, the common choice set is not adjusted. This updating process continues until either a unique price is reached or a minute has passed (at which point the communication window closes).⁵ Because in our experiment at least 20 rounds were played, we set the communication limit at one minute. In most cases, this minute was more than enough to allow subjects to reach an agreement. In Communication, Antitrust, and Leniency, the fraction of price communications that did not yield a unique agreed-upon price was 7.3%, 7.0%, and 2.7%, respectively. All price agreements were nonbinding.

Step 2. Market phase. Each subject chooses her price from the choice set $\{101, 102, \dots, 110\}$. Subjects learn the market price, being equal to the lowest of all three prices submitted.

Step 3. Reporting phase. This step only arises in Leniency. If a cartel exists, subjects have to decide whether or not to report the cartel. Each cartel member has to push either the report button or the nonreport button.⁶ In this step, no information is given about the reporting decision of other cartel members. The decision to report costs one point, irrespective of whether or not leniency is granted. This cost reflects administrative costs, legal fees, and other consultant fees that firms typically incur when filing a leniency application. Practically, levying a small reporting cost precludes a cartel member who has been undercut from punishing defectors for free.⁷

If the cartel is reported, all group members' revenues are reduced by 10% of current period revenues. Subjects can thus realize negative earnings. For instance, if price negotiations resulted in an agreed-upon price of 107, one member undercuts by quoting a price of 106, the cartel is subsequently reported, and the undercutting cartel member did not apply for leniency, its net earnings in this period would be: $(106 - 100) - 106/10 = -4.6$.

If the cartel still exists after all subjects have made their reporting decision, the cartel will be detected with 15% probability by the antitrust authority. If detected, all group members face a revenue deduction of 10% of current period revenues.⁸

All relevant information about the stage game is then displayed: submitted price, market price, revenues gross of possible revenue deduction, revenue deduction, reporting costs, and net earnings. The value of participants' total earnings is also updated and is visible at all times.

□ **Experimental procedure.** The experiment was conducted at the CREED experimental laboratory of the University of Amsterdam. There were 52 groups of three participants each (12 groups in Benchmark, 13 in both Communication and Antitrust, and 14 in Leniency). Subjects were drawn from a large pool of undergraduate students across all subject fields. Every participant was matched with the same other two subjects for a total of at least 20 periods.⁹ Subjects were randomly assigned to a treatment to ensure that there were no systematic differences in subject

⁵ Although this communication scheme is not used elsewhere, it is rooted in the related literature. For instance, in having a communication window of one minute, we are in line with Cason and Davis (1995), who allow for a two-minute communication phase.

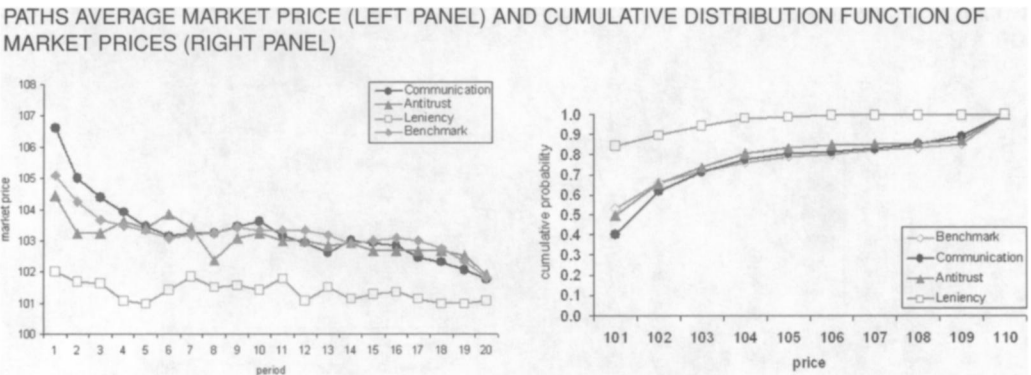
⁶ We explicitly introduced these two buttons in order to force subjects to make their reporting decision consciously.

⁷ "Free punishment" is possible in Apestequia et al. (2007), which may lead to an overestimation of the effect of leniency programs on cartel reporting.

⁸ Note that this leniency program is nonexploitable. Per-period expected cartel profits are $(110 - 100)/3 - 0.15 \cdot 0.10 \cdot 110/3 = 167/60$. These exceed per-period expected profits when applying for leniency: $(110 - 100)/3 - 1 - 0.5 \cdot 0.1 \cdot 110/3 = 1/2$.

⁹ From period 20 onward, the session ended with 20% probability, to attenuate possible final end-round effects. We analyze only the first 20 periods.

FIGURE 1



characteristics across treatments. Participants were paid their cumulative earnings in euros (with the conversion rate 1 point = €0.25) plus a €5 show-up fee. Average earnings were €14.40 and the maximum and minimum payments were €41.40 and €6.80, respectively.¹⁰ The length of the sessions was between one hour and one hour and 40 minutes.

3. Experimental results

■ **Pricing.** First we consider the impact of Leniency programs on prices. The left panel of Figure 1 shows the average price path for all four treatments. Prices decrease over time and the average price for Communication and Antitrust does not differ significantly from Benchmark ($p > 0.1$), but average prices in Leniency are considerably lower ($p = 0.019$). The plot of the cumulative distribution function (cdf) of prices depicted in the right panel of Figure 1 confirms this finding. The cdf of market prices in the other treatments clearly first-order stochastically dominates the cdf of market prices in the Leniency treatment ($p < 0.01$).

These lower prices can be due to lower cartel activity in the Leniency treatment only if the cartels in our experiment are more successful than non-cartels in charging prices above the static Nash equilibrium price. Figure 2 shows that this condition is satisfied despite the nonbinding nature of the price discussions: for Communication, Antitrust, as well as Leniency, the cdf of market prices in cartel groups first-order stochastically dominates the cdf of those in non-cartel groups ($p < 0.001$).

The figure furthermore shows that the cdf of market prices of cartel groups in Leniency is first-order stochastically dominated by the corresponding cdfs of market prices in Antitrust and Communication ($p = 0.284$ and 0.166 , respectively). That is, cooperation in cartels that do establish in the Leniency treatment is less successful than in the other treatments.¹¹

Thus, we have two potential explanations for the observed lower market prices in Leniency: first, as shown above, cartels that exist seem less successful in charging prices above the static Nash equilibrium price; and second, leniency may lead to fewer cartels being established. We investigate the latter possibility in the next subsection; in the subsection on cartel stability, we address the question why cartels in the Leniency treatment are less successful.

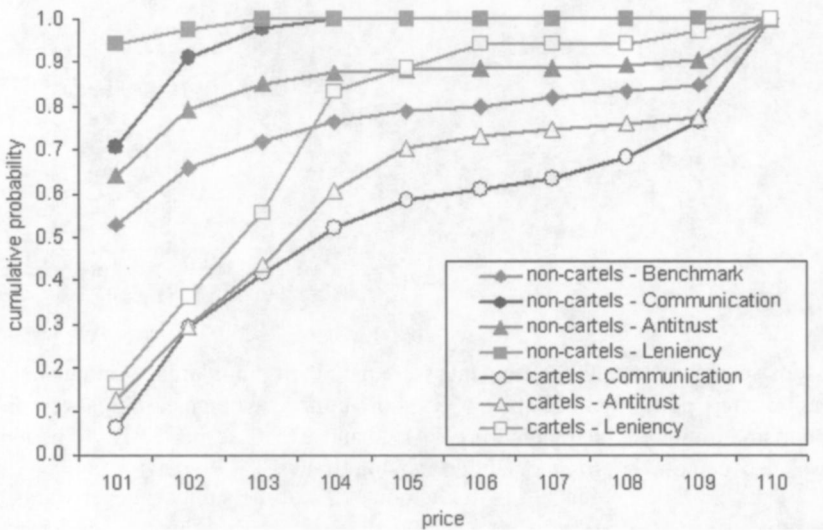
□ **Cartel activity.** The bottom row of Table 1 shows that introduction of an antitrust authority about halves the frequency of price discussions, the p value of no treatment effect

¹⁰ None of the subjects ended up with negative cumulative earnings.

¹¹ For non-cartels, average prices are higher in Benchmark than in Communication, Antitrust, or Leniency ($p = 0.076, 0.350, \text{ and } 0.036$, respectively). This can be ascribed to a selection effect: in Benchmark, subjects have no option to communicate, so that those subjects who wish to form a cartel in order to establish higher prices also end up in non-cartel groups.

FIGURE 2

CUMULATIVE DISTRIBUTION FUNCTION OF MARKET PRICES IN CARTEL AND NON-CARTEL GROUPS



versus the one-sided alternative being 0.028. Introduction of a leniency program provides a further reduction of cartel activity of about 50% ($p = 0.017$). As shown in the first row of Table 1, the alternative notion of cartel activity, that treats all situations with noncompetitive market prices as collusive, displays about the same picture. The reduction in noncompetitive prices when an antitrust authority is introduced is no longer significant, however ($p = 0.210$).

To answer the question *why* fewer cartels come into existence in the Antitrust and Leniency treatment, we first consider the development of the fraction of individual subject decisions in favor of forming a cartel for all treatments where communication is an option. The left panel of Figure 3 shows that in Antitrust, the reduction in cartel activity is related to a significant drop in the percentage of decisions in favor of price discussions relative to Communication ($p = 0.025$). In contrast, the number of subject decisions in favor of price discussions in Antitrust and Leniency are about equal ($p > 0.10$). This cannot explain the drop in cartel activity between these two treatments.

Recall that for a cartel to be formed, all three group members unanimously have to say “yes” to start price discussions. The right panel of Figure 3 shows that Leniency not only has the lowest fraction of unanimous decisions but also the highest fraction of “near unanimity” situations where price discussions are blocked because one group member refuses to communicate.

This in turn raises the question whether the experimental differences between Antitrust and Leniency lead subjects in the latter treatment to be more persistent in their choice not to collude.

TABLE 1 Average Fraction of Noncompetitive Prices and Cartels Formed

	Benchmark	Communication	Antitrust	Leniency
Noncompetitive prices ($p > 101$)	0.47 (0.36)	0.60 (0.31)	0.50 (0.29)	0.16 (0.14)
Cartels	- (-)	0.47 (0.30)	0.27 (0.20)	0.13 (0.13)

Standard errors within parentheses.

FIGURE 3

PER-PERIOD AVERAGE FRACTION OF SUBJECTS WHO WISH TO FORM A CARTEL (LEFT PANEL) AND A HISTOGRAM OF THE NUMBER OF GROUP MEMBERS AGREEING TO FORM A CARTEL (RIGHT PANEL)

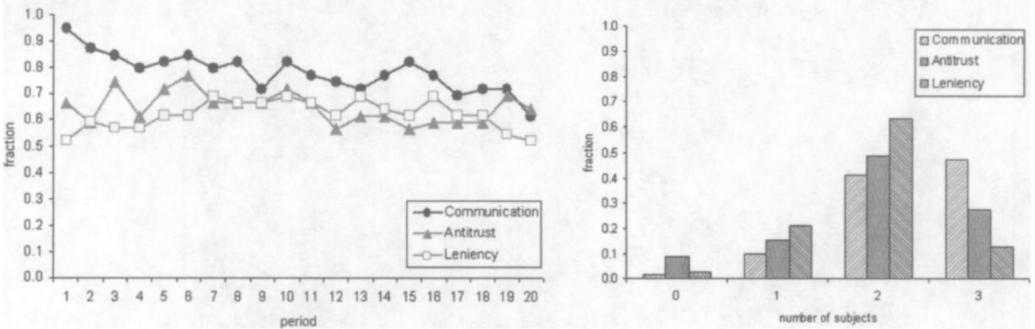


Figure 4 addresses this question by mapping the cdf of the number of times each subject consents to discussing prices. Whereas in Communication and Antitrust all subjects consent to discuss prices at least once, in the Leniency treatment about 10% of the subjects never wants to discuss prices. Their persistence successfully blocks some of the cartels, although the difference between the cdfs of Leniency and Antitrust is not significant ($p = 0.402$).

□ **Cartel stability.** In this section, we limit attention to the cartels that do form in order to explain why cartels in Leniency are less successful in establishing high market prices. The cdfs of the agreed-upon prices in the communication phase of the different treatments (Figure 5) do not reveal a significant difference of subjects' behavior in the price discussions ($p = 0.230$): in all treatments, 67%–83% of the subjects agrees to charging the monopoly price of 110.

Apparently, if no differences in agreed-upon prices are observed but market prices in Leniency are considerably lower, cartel members in Leniency defect more often and/or undercut

FIGURE 4

CUMULATIVE DISTRIBUTION FUNCTION OF THE NUMBER OF PERIODS INDIVIDUAL SUBJECTS WANT TO COLLUDE

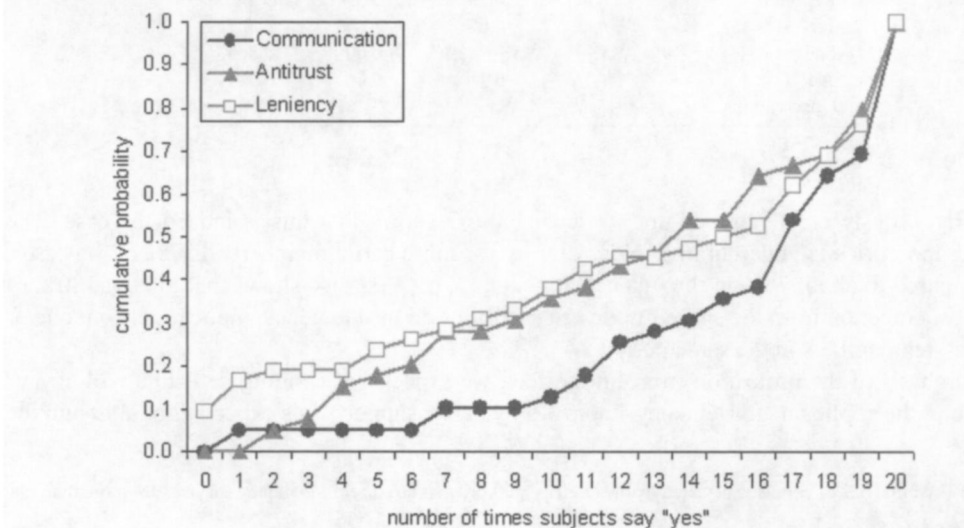


FIGURE 5

CUMULATIVE DISTRIBUTION FUNCTION OF THE AGREED-UPON PRICES BY CARTEL MEMBERS

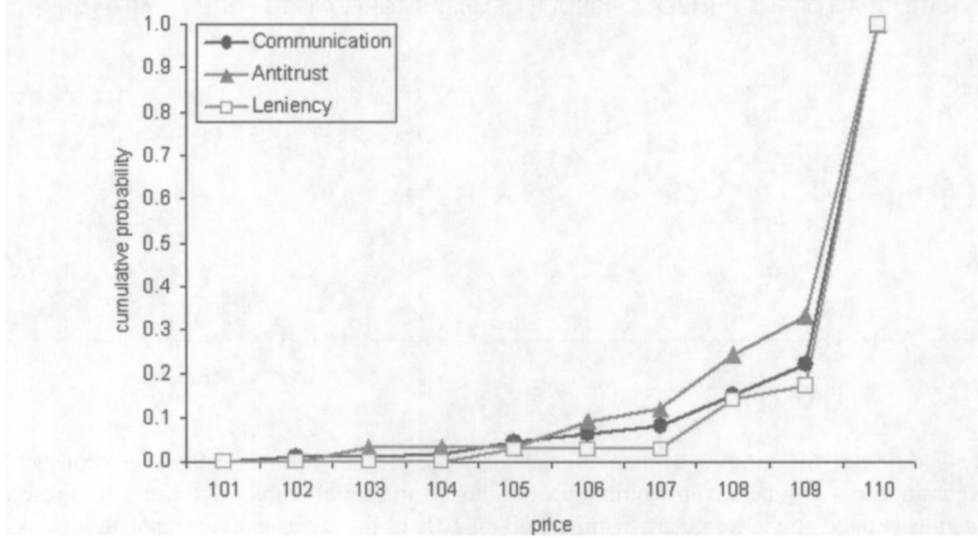


TABLE 2 Causes of Cartel Breakdowns

	Fraction of Cartels		
	Defection	Detection	Reporting
Communication	0.72	–	–
Antitrust	0.75	0.17	–
Leniency	0.97	0.03	0.78

TABLE 3 Fraction of Leniency Applications in Leniency among Winning and Nonwinning Defectors and Compliers

	Defect		Comply	
	Win	Not Win	Win	Not Win
Report	0.51	0.29	0.33	0.37
1st	0.67	0.67	1.00	0.56
2nd	0.25	0.22	0.00	0.33
3rd	0.08	0.11	0.00	0.11
Observations	47	31	3	24

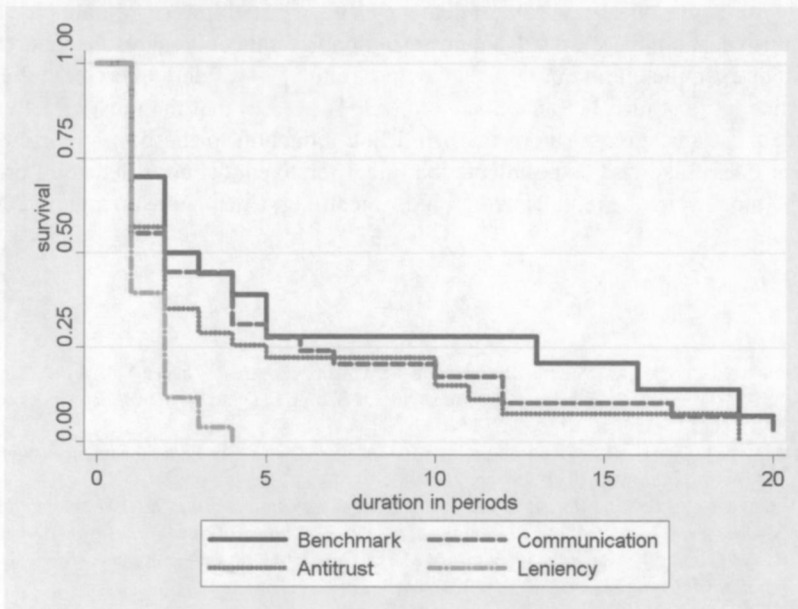
more rigorously on the agreed-upon prices. Table 2 shows that this is indeed the case. The agreed-upon price is undercut in Leniency by one or more cartel members in 97% of the cases, as compared to about 75% in the other treatments.¹² The table also shows that in about 80% of all cases, defection from the agreed-upon price is followed by a leniency application from one or more cartel members in the same period.

On basis of the protection-from-fines effect, we expect that winning defectors will always be among the applicants for leniency. Table 3 only partly supports this expectation: although the

¹² The other 3% of cartels is detected by the antitrust authority so no cartel in Leniency survives for more than one period.

FIGURE 6

KAPLAN-MEIER SURVIVAL ESTIMATES BY TREATMENT



percentage of leniency applications in the pool of winning defectors, 51%, is considerably higher than in the other groups ($p = 0.029$), only about half of the winning defectors file for leniency.

All this should affect the duration of cartels. To estimate the cartel survival rate, however, the above definition of cartels is ambiguous, as it is unclear whether sequential periods with price discussions and lower-than-agreed market prices constitute the same cartel or not. Figure 6 therefore displays the Kaplan-Meier cartel survival estimates, with all prices above 101 treated as collusive. The estimated survivor functions are not different for Benchmark, Communication, and Antitrust ($p = 0.37$). But the log-rank test clearly rejects equality across treatments when Leniency is included ($p = 0.00$). That is, the probability that the market price exceeds 101 for any number of consecutive periods is much lower in Leniency than in any other treatment. An alternative test that defines cartel duration as the number of periods between the first successful price discussions and the first period in which market price is lower than the most recent agreed-upon price leads to similar results. Equality of the survival functions can in this case not be rejected due to the stricter definition of cartel breakdowns. This shortens considerably the recorded cartel lifetime, thereby eliminating most of all variation across treatments.

4. Concluding remarks

■ The study explores the effects of moderate corporate leniency programs on pricing and cartel activity. We find that introduction of a leniency program leads to lower prices for two reasons. First, putting a leniency program in place leads to a reduction in cartel activity. A notable difference from the other treatments is that in the Leniency treatment, about 10% of the subjects refuses to discuss prices throughout the experiment. Second, those cartels that are established are less successful in charging prices above the static Nash equilibrium price. This is not caused by differences in behavior in the communication phase but by more frequent and more severe undercutting of the agreed-upon price in the market phase. This behavior in turn is related to the shorter cartel lifetime in the Leniency treatment; the probability that the market price exceeds the competitive level for any number of consecutive periods is significantly lower in Leniency.

The data furthermore indicate that defectors use the leniency program to receive protection from fines.

As noted by Spagnolo (forthcoming), “more empirical and experimental evidence would be extremely welcome on all aspects of leniency and whistleblower programs.” This article responds to this wish, but there are still a number of important theoretical results that remain to be scrutinized. For example, although the leniency program we considered here complies with the current practice in most jurisdictions, Spagnolo (2004) stresses that the most effective leniency programs are those that give a (more than) full fine reduction to the first applicant and none to subsequent ones. Likewise, experiments that incorporate endogenous detection probabilities would also be most welcome (e.g., Harrington, forthcoming; Chen and Harrington, 2007).

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