Trust, Leniency and Deterrence*

M. Bigoni[†] S-O. Fridolfsson[‡] C. Le Coq[§] G. Spagnolo[¶]

February 6, 2014

Abstract

This paper presents results from a laboratory experiment studying the channels through which different law enforcement strategies deter cartel formation. With leniency policies offering immunity to the first reporting party, a high fine is the main determinant of deterrence, having a strong effect even when the probability of exogenous detection is zero. Deterrence appears to be mainly driven by 'distrust'; here, the fear of partners deviating and reporting. Absent leniency, the probability of detection and the expected fine matter more, and low fines are exploited to punish defections. The results appear relevant to several other forms of crimes that share cartels' strategic features, including corruption and financial fraud.

KEYWORDS: Antitrust, Betrayal, Cartels, Collusion, Distrust, Fines, Leniency, Whistleblowers.
JEL CODES: C92, D03, K21, K42, L41

*Many thanks to Tore Ellingsen, Dirk Engelmann, Joe Harrington, Benedikt Herrmann, Magnus Johannesson, Dorothea Kübler, Massimo Motta, Hans-Theo Normann, Henrik Orzen, Nicola Persico and Georg Weizsaker for discussions and advice related to this project, and to audiences in Amsterdam (ACLE Conference, 2010), Berlin (WZB/RNIC Conference, 2008), Bologna, Gothenburg (Second Nordic Workshop in Behavioral and Experimental Economics, 2007), Mannheim (MaCCI Inaugural Conference 2012), Milan (EEA/ESEM Meeting, 2008), Mölle (SNEE, 2010), Princeton (ALEA Meeting, 2010), Rome (World ESA Meeting 2007, IAREP/SABE World Meeting 2008), Stockholm (EARIE 2011 and Konkurrensverket), Tilburg, and Vancouver (IIOC Meeting, 2010). We also gratefully acknowledge research funding from Konkurrensverket (the Swedish Competition Authority) that made this research possible.

[†]University of Bologna, maria.bigoni@unibo.it

[‡]Research Institute of Industrial Economics (IfN), Sven-Olof.Fridolfsson@ifn.se

[§]Stockholm School of Economics, SITE, chloe.lecoq@hhs.se

[¶]Tor Vergata University, Stockholm School of Economics, SITE, and CEPR, giancarlo.spagnolo@uniroma2.it

1 Introduction

Cartels, like most other forms of organized economic crime (corruption, fraud, smuggling...), require effective cooperation between multiple wrongdoers. Being profitable in expectation is therefore not sufficient for them to be viable. Because illegal contracts cannot be enforced, the cooperative agreement must also be sustainable in equilibrium: each wrongdoer must prefer to respect the agreement rather than unilaterally deviate from it by 'running away with the money' (Stigler 1964). Moreover, the wrongdoers must coordinate on the cooperative equilibrium and trust that their partners, for the entire period of collaboration and afterwards, will not get "cold feet" and report to law enforcers.[1] A further peculiarity of crimes like these is that there are always 'witnesses': cooperating wrongdoers typically end up having information about each other that could be elicited through suitably designed incentives to report.

These features imply that deterrence can be achieved through a number of channels. While individual crimes must be deterred by large enough expected sanctions (Becker 1968) – so that the individual Participation Constraint (PC) is violated – crimes like cartels can be deterred also:

- by ensuring that at least one co-offender's Incentive Compatibility Constraint (ICC) is violated, so that the crime – although profitable in expectation – is not an equilibrium; or

- by worsening the 'Trust Problem' (TP), i.e. each wrongdoer's fear that his partners will not stick to the illegal agreement, even if it is an equilibrium.

This paper reports results from an experiment investigating the cartel deterrence effects of changes in the level of fines and in the probability of detection by the competition authority, with and without a leniency policy that offers immunity to the first party to report the cartel. Beyond the novelty and direct policy relevance of the questions themselves, the answers may help shed light on which deterrence channels are more relevant in different legal environments.

We simulate a cartel formation game in the laboratory in which subjects play a repeated duopoly with uncertain end, and can choose whether or not to communicate illegally to

[1] Spagnolo (2004) analyzes this channel theoretically. See also Harrington (2013), where the fear of being betrayed may also induce reporting because cartel members, unlike in our environment, observe private signals on the probability of being detected by a random audit. That criminal organizations require trust to function and pursue their illegal endeavors has been noted also by several legal scholars (see e.g. Leslie 2004, Von Lampe and Johansen 2004, and references therein).

fix prices. If players choose to communicate, they are considered to have formed an illegal conspiracy and fall liable to fines.[2] We adopt the same basic environment developed in Bigoni et al. (2012), which investigates the deterrence and price effects of offering either leniency or rewards to the first party reporting the cartel to law enforcers. Because of constant levels of the fine (F) and the probability of detection through a random audit (α), that study cannot answer the research questions we address here. To try to identify the Trust channel of deterrence, we use data from four benchmark treatments in Bigoni et al. (2012) and run four additional treatments with different levels of α and F. The resulting eight treatments included in the current study differ: i) in the presence and size of F; ii) in the level of α; iii) in the possibility and consequences of betraying partners by reporting information to the authority; and iv) in the possibility to obtain a lenient treatment by reporting.

In line with (our and others') previous experimental studies, we find that schemes granting leniency to the first wrongdoer that spontaneously 'turns in' his partners before any investigation is opened, strongly increases deterrence. The novel finding of this work is that the size of the fine *per se* plays a critical role in cartel deterrence, independent of its influence on the expected fine and distinct from that of the probability of detection by the competition authority, in particular when leniency is available. In turn, this suggests that the presence of leniency tends to shift the balance between the different deterrence channels in favor of the Trust Problem. We find that under standard law enforcement policies, i.e. absent leniency, deterrence is more sensitive to changes in *the expected fine* (αF), as predicted by classic 'Beckerian' law enforcement theory, than in the fine (F) itself (crime becomes less profitable in expectation and the PC is tightened). With leniency in place the expected fine also affects deterrence, but *the actual fine* F becomes even more important in driving behavior. Wrongdoers react less to changes in the probability of detection α when leniency is in place, most likely because they are more worried about the probability of being betrayed by fellow cartelists. Most strikingly, we observe a significant direct deterrence effect of F, *even when* α *equals zero,* that becomes much stronger when leniency is in place. This result stands in open contrast with the classic theory on deterrence of individual crimes (Becker 1968) which asserts that law enforcement produces no deterrence whatever the level of the fine if α equals zero.[3]

[2]The subjects in principle could collude tacitly and thereby reap the gains from cooperation without running the risk of being caught. As discussed below however, our data suggests that they were unable to do so.

[3]Note that more recent models where subjects may also report in equilibrium to preempt others from

Our findings suggest that the possibility of being reported increases the fear and cost of being betrayed: the Trust Problem becomes more salient than other considerations. This is especially the case with leniency policies, because they increase the incentive to report. We also find that in the absence of leniency, low fines and the possibility to report to law enforcers are used as a costly punishment to discipline cartel deviations; for sufficiently low fines deterrence falls with the fine even if the expected fine does not.

To the extent that these results are confirmed in future studies and apply outside the laboratory, they have important policy implications. They suggest that leniency policies limited to the first party that spontaneously reports, as in the US before the 1993 reform, could significantly increase the efficiency of law enforcement if coupled with sufficiently robust sanctions (and if well advertised; both of these additional conditions were not met by the US program before 1993). The results also point to the importance of complementing leniency-based revelation schemes with sufficiently severe sanctions rather than with a high probability of detection. The possibility that the recent and numerous leniency applications could undermine cartel deterrence by keeping competition authorities too busy to undertake independent audits (reducing α, see Riley 2007 and Chang and Harrington 2010) may in turn be less worrisome if sanctions are sufficiently robust and/or can be further strengthened. Our results also suggest that a legal system without leniency could be strategically exploited to punish deviations and stabilize - rather than deter - cartels and similar crimes in jurisdictions where sanctions are relatively low. Finally, the smaller but positive deterrence effect observed in the absence of leniency when α equals zero contradicts our theoretical predictions (and we see no clear alternative interpretation for it, a hint that additional effects may be at play). Thus, there is scope and need for additional theoretical and experimental studies.

Our work contributes to a recent experimental literature evaluating the hard-to-measure deterrence effects of differently designed leniency policies against cartels, which includes Apesteguia et al. (2007), Hamaguchi et al. (2007), Hinloopen and Soetevent (2008), Krajčová and Ortmann (2008), Hamaguchi et al. (2009), and Bigoni et al. (2012) among others.[4] These studies are based on the theoretical literature on leniency policies in an-

doing so before them because of private signals, starting with Harrington (2013), would also predict no deterrence effects with α equal zero. Here and in Spagnolo (2004), instead, a fine has deterrence effects even when α equals zero because it increases strategic risk through the cost of being betrayed. This affects equilibrium selection in favour of a safer equilibrium, not colluding.

[4] Our work is also related to experiments on collusion and oligopoly like Huck et al. (1999), Offerman et al. (2002), Huck et al. (2004), Engelmann and Müller (2011) and Potters (2009). A recent experimental study by Schildberg-Hörisch and Strassmair (2012) also deals with deterrence, but focuses on a single

titrust, which extends to multi-agent conspiracies Kaplow and Shavell (1994)'s seminal analysis of self-reporting for individual crimes.[5] To our knowledge, ours is the first experiment to consider different levels of fines and probabilities of apprehension along with leniency policies. It is also novel in trying to disentangle the role of distrust from other possible channels through which law enforcement instruments may deter collaborative crimes.

Further our work relates to the large experimental literature on trust, surveyed in Fehr (2009). This literature suggests that trust is determined by various factors, including social preferences, fairness, guilt aversion and beliefs about others' trustworthiness.[6] The concept typically has a positive connotation, since the focus of most studies is on pro-social forms of cooperation (see Gambetta 2000, and Knack and Zak 2003). In our context, trust is instead costly for society, and its most relevant component is probably 'trust as beliefs' (Fehr 2009; Sapienza et al. 2013) in that it defines the perceived likelihood that a partner wrongdoer sticks to the criminal plan rather than betrays the conspiracy.

The remainder of the paper proceeds as follows: The experimental design and procedures are described in Section 2. Section 3 (and the Appendix) derives theoretical predictions that form the benchmark for our tests. Section 4 reports the results and Section 5 concludes, discussing policy implications and avenues for future research. An online appendix, containing details about the experimental sessions, our empirical methodology, and the instructions for one of our leniency treatments, complements the paper.

2 Experimental Design

The purpose of our experiment is to test the cartel deterrence effects of the fines and of the probability of detection by the competition authority. We adopt the same basic environment developed in Bigoni et al. (2012) and add treatments with new levels of the fine and the probability of detection.

decision of a single individual who can steal from another, an environment where the strategic aspects at the core of our paper are not present, while important distributional concerns emerge.

[5]See Spagnolo (2004) for a theoretical study close to our experimental set-up. This literature, initiated by Motta and Polo (2003), highlights several possible reasons behind the apparent success of such policies but also some potential counterproductive effects, generating a number of questions hard to address empirically. See Rey (2003) and Spagnolo (2008) for surveys. Brenner (2009) and Miller (2009) attempt to empirically identify the deterrence effects of leniency policies by looking at changes in the rate of detected cartels after the introduction of such policies. See also Chang and Harrington (2010), who introduce an alternative methodology based on observed changes in duration of detected cartels.

[6]See e.g. Berg et al. (1995), Fehr and List (2004), Kosfeld et al. (2005), Charness and Dufwenberg (2006), Falk and Kosfeld (2006) and Guiso et al. (2008) among others.

Subjects were randomly matched in pairs, playing in(de-)finitely repeated duopoly games.[7] Each stage-game consisted of four major steps: communication, price choices, self reporting, and detection (Figure 1).

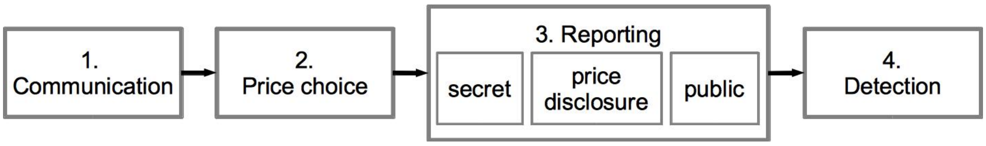


Figure 1: Steps of the stage game.

First, subjects could form a cartel by choosing to communicate on prices. If so, they had 30 seconds to agree on a non binding price, corresponding to the minimum between the last two prices proposed by the subjects.[8] This restricted protocol kept the communication phase reasonably short and speeded up play, a critical design concern given the necessary but unusual length and complexity of our stage game relative to any previous experimental study of indefinitely repeated games.

Second, subjects had 30 seconds to simultaneously choose a price in the range 0,..,12 yielding the payoffs in Table 1; the default price induced zero profit for subjects failing to choose a price. The payoff table, also used in Bigoni et al. 2012, is derived from a standard price game with differentiated products and has a unique Bertrand equilibrium with each firm charging a price of 3 and receiving a profit of 100. The joint profit maximizing price is 9, yielding profits of 180.

Third, cartel members were given two opportunities to report the cartels they formed in the current period, or those formed in previous periods that had not yet been detected. A first opportunity to "secretly" report was given right after the price choice, but before

[7]A duopoly market contributed to simplifying an already complex strategic environment, hopefully helping the subjects to focus on the variables of interest for our research questions. This design choice involved a risk, however, as tacit collusion is generally easier to achieve in duopolies than in larger experimental markets (Huck et al. 2004). One reason is probably the "reduced ability to punish a deviant competitor in large-number situations" (Holt 1995, p.419). This problem is particularly severe in laboratory experiments, because of the lack of geographical dispersion of simulated markets, and of the possibility that subjects care for other non-defecting subjects and therefore refrain from punishing a defector so as not to harm non-defectors. But since punishments play a central role in our study, this argument also provides a reason for our duopoly choice. And most importantly, the experimental data validate our choice as subjects appeared unable to collude tacitly (see Section 4).

[8]Subjects first stated simultaneously a minimum acceptable price in the range $\{0,..,12\}$. When both had stated a price, they chose again a price from the new range $\{pmin,...,12\}$, where $pmin$ equaled the minimum of the two previously chosen prices. This communication continued until time was up. In this way, no subject was forced to collude on a price considered too high. And, they agreed on a minimum acceptable price in a reasonably short lapse of time: in 47.9% of the instances, the two subjects ended up proposing exactly the same price.

this price choice was disclosed to the competitor. Combining a price deviation with such a report constituted an optimal deviation under leniency, as it eliminated the risk of being detected exogenously by the competition authority or through the second reporting opportunity.[9] We refer to this second reporting opportunity as "public" because it arose after price choices (and thus possible price deviations) became public information, and was only available if no cartel member had previously reported their cartel secretly. This public report opportunity, if available, could then be used as a punishment against a deviator that did not report.

Finally, cartels that had not yet been reported, could be detected and convicted by a competition authority, with probability α. At the end of each period the screen displayed the agreed price, the two players' price choices, the number of reports, eventual fines and net profits.

		your competitor's price												
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
your price	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	29	38	47	56	64	68	68	68	68	68	68	68	68
	2	36	53	71	89	107	124	128	128	128	128	128	128	128
	3	20	47	73	100	127	153	180	180	180	180	180	180	180
	4	0	18	53	89	124	160	196	224	224	224	224	224	224
	5	0	0	11	56	100	144	189	233	260	260	260	260	260
	6	0	0	0	0	53	107	160	213	267	288	288	288	288
	7	0	0	0	0	0	47	109	171	233	296	308	308	308
	8	0	0	0	0	0	0	36	107	178	249	320	320	320
	9	0	0	0	0	0	0	0	20	100	180	260	324	324
	10	0	0	0	0	0	0	0	0	0	89	178	267	320
	11	0	0	0	0	0	0	0	0	0	0	73	171	269
	12	0	0	0	0	0	0	0	0	0	0	0	53	160

Table 1: **Profits in the Bertrand game**

A session lasted for at least 20 periods in total, and potentially included several supergames (or matches). At the end of each stage game there was an 85% probability that the match continued for an additional period, and a 15% probability that the match ended. If the match ended, all pairs of subjects were dismantled and cartels formed in previous periods were no longer liable for fines. Subjects were then randomly matched again into pairs and played a new supergame, unless 20 periods or more had passed. At that point

[9]The ability to both secretly undercut the collusive price and to self report before the secret price cut becomes public is a crucial feature of leniency programs that sometimes has been overlooked, in theory and in experiments. This ability generates deterrence because it increases incentives to both deviate and report, an effect known as the "protection from fines effect" (Spagnolo 2004).

the experiment ended.[10] This procedure allowed us to observe the subjects' behavior in several repeated games, and how behavior evolved with experience.[11]

We ran 8 treatments (summarized in Table 2) differing in the probability of detection, α, the level of the fine, F,[12] and in the possibility to report. In all treatments, both cartel members paid the fine F if detected by the competition authority. The effect of a report depended instead on the law enforcement institution. In the Fine treatments, meant to capture traditional law enforcement, the fine F was paid by both cartel members (including the reporting one). In the Leniency treatments, if only one member reported the cartel, this member did not pay the fine whereas the other member paid the full fine. Both cartel members paid a reduced fine if instead both reported the cartel simultaneously; this reduced fine equaled $F/2$, corresponding to the expected fine if only the first reporting member was granted (full) immunity and both cartel members were equally likely to report first.

We ran three treatments for each of these law enforcement institutions. Two treatments had the same expected fine, $\alpha F = 20$, the fine being high ($F = 1000$) and the probability of detection low ($\alpha = 0.02$) in one treatment whereas $F = 200$ and $\alpha = 0.1$ in the other treatment. The third treatment had a high fine $F = 1000$ but a 0 probability of detection so that the expected fine αF equaled 0. Besides these 6 treatments we ran a benchmark treatment, L-Faire, corresponding to a *laissez-faire* regime where $\alpha = F = 0$. Cartels were thus allowed (but not legally enforced) in L-Faire and, to simplify instructions, subjects were not given the opportunity to report. Finally, we ran NoReport, a Fine treatment with $\alpha = 0.1$ and $F = 200$ but where cartel members could not report their cartel, neither secretly nor publicly.

A total of 256 students from Tor Vergata University (Rome, Italy) participated voluntarily in this experiment. In each session, 32 subjects interacted anonymously via computer using the software Z-Tree (Fischbacher 2007). Subjects participated in only one treatment and were paid in private at the end of each session. Subjects started with an initial endowment of 1000 points in order to reduce the likelihood of bankruptcy. At the end of the experiment, subjects were paid an amount equal to their cumulated earnings (including

[10] To pin down expectations on very long realizations, subjects were also informed that the game would end after 2 hours and 30 minutes. This possibility was unlikely and never occurred.

[11] All subjects in a session could in principle compete with each other. Each session therefore constitutes an independent observation. To account for possible dependencies across observations we adopt a parametric approach in the data analysis (see Section B.2 in the online Appendix).

[12] F is fixed, to account for fixed components of real antitrust fines and to eliminate uncertainty about their size.

Treatment	fine (F)	probability of detection (α)	report	report's effect
FINE	200†	0.10†	Yes	pay the full fine
	1000	0.02		
	1000	0		
LENIENCY	200†	0.10†	Yes	no fine (half the fine if both report)
	1000	0.02		
	1000	0		
L-FAIRE	0†	0†	No	–
NOREPORT	200†	0.10†	No	–

† Data from these sessions were also used in Bigoni et al. (2012).

Table 2: **Treatments**

the initial endowment) plus a show-up fee of €7. The conversion rate was 200 points for €1. The average payment in the main game was €24.18, with a minimum (maximum) of €11 (€34). Additional information on the experimental sessions is provided in Table B.1 of the online Appendix B.1.

3 Theoretical predictions and Hypothesis

Our design ensures that forming a cartel by communicating on prices is an equilibrium in all treatments (see Appendix A.1). However, the incentives to participate and to sustain collusion vary under different reporting regimes, as does the cost of being betrayed by a trusted partner.

Standard Equilibrium Conditions and Deterrence The participation constraint (PC) and the incentive compatibility constraint (ICC), two necessary conditions for the existence of a collusive equilibrium, provide valuable insights about possible effects of law enforcement institutions. All else equal, the PCs in FINE and LENIENCY treatments are identically tighter than in L-FAIRE due to the expected fine payment. Moreover the ICCs are tighter in LENIENCY than in FINE or in L-FAIRE, since a deviation in LENIENCY is optimally combined with a secret report providing protection against the fine.[13]

[13] Appendix A.1 provides a formal analysis underlying these claims. See also Spagnolo (2004) for an in-depth discussion.

The ICCs presume that agents are perfectly able to coordinate on the collusive equilibrium. Even if cooperation constitutes an equilibrium, agents could however be discouraged from forming a cartel by the fear of miscoordination, and even more by the fear of being 'cheated' by the opponent. Recent theoretical and experimental work has highlighted that the fear of being cheated and receiving the 'sucker's payoff' constitutes a critical determinant of subjects' decisions to cooperate (Blonski and Spagnolo forthcoming; Bohnet et al. 2008; Blonski et al. 2011; Dal Bó and Fréchette 2011).

Indeed, we show next, in the spirit of Spagnolo (2004), that the demand for trust required to enter an illegal price-fixing conspiracy varies across law enforcement regimes.[14]

Demand for Trust and Deterrence Assume that a subject believes that, following communication on the collusive price, his opponent will undercut the agreed price with some probability $(1-\beta)$. The complementary probability β can be viewed as the agent's 'belief component of trust' in a partner conspirator (see e.g., Fehr 2009, Sapienza et al. 2013). The *minimum level of trust*, β_K, required to make price-fixing collusion profitable and sustainable in treatment $K \in \{L-Faire, Fine, Len\}$ can then be viewed as a measure of the 'demand for trust' in this treatment. Collusion is then sustainable if $\beta \geq \beta_K$.

Let V_K^{ss} (V_K^{ds}) denote the values of sticking to (deviating from) the collusive agreement in treatment K, assuming the opponent is trustworthy (i.e., sticks to the agreement). Similarly, let V_K^{sd} and V_K^{dd} denote these values, assuming instead that the opponent is not trustworthy (i.e., undercuts the agreed price). Then β_K is defined by the equality $\beta_K V_K^{ss} + (1-\beta_K)\, V_K^{sd} = \beta_K V_K^{ds} + (1-\beta_K)\, V_K^{dd}$, or equivalently

$$\beta_K = \frac{\left(V_K^{dd} - V_K^{sd}\right)}{\left(V_K^{dd} - V_K^{sd}\right) + \left(V_K^{ss} - V_K^{ds}\right)}. \tag{1}$$

β_K is thus determined by two components, $V_K^{ss} - V_K^{ds}$ and $V_K^{dd} - V_K^{sd}$. This measure corresponds to the 'basin of attraction' or 'resistance' of the cooperative strategy as defined in evolutionary game theory (see Myerson 1991, sect. 7.11) and to the measure of strategic "riskiness" of cooperation developed in Blonski and Spagnolo (forthcoming).[15] Presumably subjects are less willing to form cartels when the demand for trust increases. A reasonable

[14] An alternative approach capturing deterrence driven by the fear that others report, already mentioned in the introduction and which we did not follow here, would be to allow subjects to have private information on the probability of exogenous detection (α), as in Harrington (2013).

[15] Blonski et al. (2011) and Dal Bó and Fréchette (2011) provide experimental evidence in support of the effective predictive power of these measures in repeated games.

conjecture is thus that deterrence increases as β_K increases (as the basin of attraction shrinks).

Appendix A.2 provides a formal expression for β_K and characterizes for each treatment the minimum level of trust, showing that $\beta_{L-Faire} = \beta_{Fine} < \beta_{Len}$. The amount of trust required by the price-fixing conspiracy is thus higher in LENIENCY (but not in FINE) than in L-FAIRE. The reason is that an optimal deviation is combined with a simultaneous report only under LENIENCY, and this increases the cost of being betrayed relative to FINE.

Hypotheses Under the assumption that stricter equilibrium conditions make it harder to sustain the equilibrium, deterrence should be stronger in treatments where the PC and ICC are tighter and the demand for trust is higher. This implies that, given α and F, deterrence is lowest in L-FAIRE, followed in order of magnitude by FINE and LENIENCY. The deterrence effect of FINE relative to L-FAIRE is driven only by different PCs. Both the ICC and the minimum level of trust drive the higher deterrence effect of LENIENCY relative to FINE.

To disentangle the effects of the ICCs and the minimum level of trust, we explore the deterrence effects of changes in α and F, taking the policy as given. An increase in the *per period expected fine* αF increases the *discounted expected fine payment* (EF) and thereby tightens the PC for all policy treatments. The effects on the ICC and on β_K, however, depend on whether the policy includes leniency. Absent leniency, the change has no effect, either on the ICC, or on β_{Fine} since the expected fine payment EF is the same under FINE whether one, two, or no cartel member undercuts the agreed price. By contrast, the ICC is tightened under LENIENCY, since a deviation combined with a secret report protects against the increased expected fine payment, EF. For the same reason, β_{Len} also increases. These observations are discussed formally in Appendix A.3 and lead to our first hypothesis.

Hypothesis 1 (increased expected fine) An increase in the per period expected fine

- **H1$_L$:** increases deterrence under LENIENCY;
- **H1$_F$:** increases deterrence under FINE but less than under LENIENCY.

To understand if an increase in F per se affects deterrence when a leniency program is present, consider first an increase in F compensated by a fall in α, so as to keep αF

constant. Accounting for the possibility of being fined in several periods, such a change tightens the PC slightly in all policy treatments (see Appendix A.4). This dynamic effect is subtle, difficult to compute and not very intuitive, as EF increases despite the fact that the per period expected fine αF is constant. One may therefore expect that subjects perceived this as a neutral change. By contrast the change also tightens the ICC in LENIENCY and increases β_{Len}. The effect on β_{Len} may be particularly strong as the increase in F *per se* lowers the sucker's payoff by increasing the cost of being betrayed (since a defecting subject also reports the cartel, which increases $V^{dd}_{Len} - V^{sd}_{Len}$). These observations, of which we give a more formal treatment in Appendix A.4, lead to our second hypothesis.

Hypothesis 2 (constant expected fine) An increase in F compensated by a fall in α so as to keep the per period expected fine constant

H2$_L$: increases deterrence under LENIENCY;

H2$_F$: increases deterrence (weakly) under FINE but less than under LENIENCY.

Main experimental hypotheses. Let us now turn to our central experimental hypothesis. The treatments when $\alpha = 0$ (but $F > 0$) are particularly useful in disentangling the different potential deterrence channels discussed so far. The subtle dynamic effect discussed in connection to Hypothesis 2 is not present as both EF and αF equal zero. According to the PC and the ICC, FINE and LENIENCY should therefore have no deterrence effect relative to L-FAIRE. Instead, the sucker's payoff is much worse under LENIENCY only and therefore increases the demand for trust in that treatment only. This motivates our last hypothesis (see also Appendix A.5).

Main Hypothesis (zero expected fine) With a zero probability of detection, a positive fine

MH$_L$**:** generates deterrence under LENIENCY;

MH$_F$**:** does not generate deterrence under FINE.

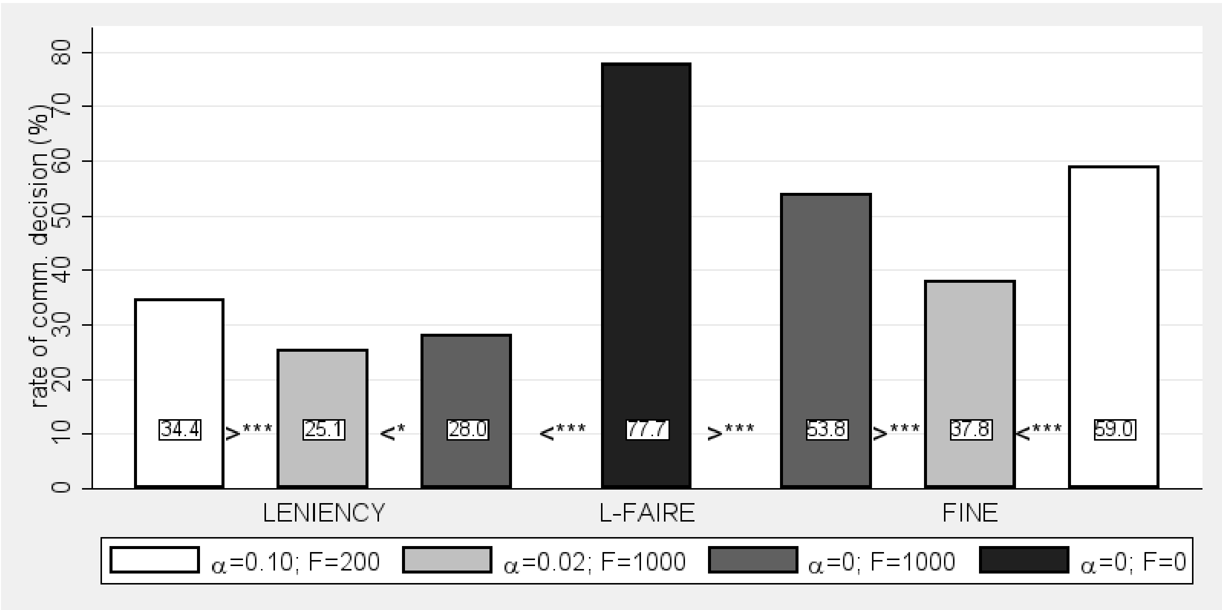
There is an additional reason why this hypothesis is the core of our paper. It stands in sharp contrast with the standard intuition of most previous work in law and economics which, starting from Becker (1968), focuses mostly on individual crime. One of the classic results of this literature is that the first best cannot be achieved even with infinite fines because (i) α must be positive for fines to have any effect and (ii) a strictly positive α

constitutes a deadweight loss for society as resources must be devoted to detecting the criminal activity. Our Main Hypothesis therefore marks a stark qualitative difference with this large body of previous work. If supported, it suggests that with organized crime, the first best can be achieved with an appropriate combination of well designed leniency policies and robust (finite) sanctions.

4 Results

Figure 2 provides an overview of how the legal framework affected the subjects' decisions to communicate (given that a cartel was not yet formed), that is their attempts to form cartels, in our seven main treatments. Its most striking feature is probably that the introduction of a positive and substantial fine ($F = 1000$) induced deterrence even with a probability of detection α equal to 0, particularly when a leniency program was in place.

Figure 2: Rates of communication decision



Note: The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

The introduction of a positive but small probability of detection ($\alpha = 0.02$) increased deterrence primarily in the Fine treatment. A reduction in the fine ($F = 200$), compensated by an increase in the probability of detection so as to keep the expected fine constant ($\alpha F = 20$), decreased deterrence both with and without leniency.

The figure also reports statistical tests on the differences in the rates of communication decisions across treatments. These tests are based on *logit* regressions with 3-level random effects, to account for potential correlations among observations from the same subject and from the same duopoly. Regression results are reported in Tables 3a-3c.

	FINE	LENIENCY
$\alpha = 0;\ F = 1000$	-0.160***	-0.440***
	(0.040)	(0.005)
Log-Likelihood	-570.526	-680.948
N	1108	1350

(a) L-FAIRE vs. $[\alpha = 0;\ F = 1000]$

	FINE	LENIENCY
$\alpha = 0.02;\ F = 1000$	-0.311***	-0.071*
	(0.063)	(0.041)
Log-Likelihood	-416.821	-660.115
N	838	1414

(b) $[\alpha = 0;\ F = 1000]$ vs. $[\alpha = 0.02;\ F = 1000]$

	FINE	LENIENCY
$\alpha = 0.10;\ F = 200$	0.328***	0.141***
	(0.050)	(0.049)
Log-Likelihood	-524.298	-781.619
N	1010	1552

(c) $[\alpha = 0.02;\ F = 1000]$ vs. $[\alpha = 0.10;\ F = 200]$

Note: Results from logit regressions with three-level random effects. Each regression compares pairs of treatments to assess the size and significance of the impact that a change in the size of the actual and expected fine has on deterrence, with and without leniency programs. The dependent variable is the binary decision whether to communicate or not when subjects would not otherwise be liable for collusion. The main independent variable is a dummy taking value one for the treatment of interest, and zero for the reference treatment. Standard errors are robust for heteroskedasticity. See the online Appendix B.2 for further details. The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 3: Differences in deterrence across treatments.

We will return to Figure 2 throughout the discussion of our results. Before doing so, two remarks are warranted. First, the policy effects are consistent with the theoretical predictions; given α and F, FINE increases deterrence relative to L-FAIRE but less so than LENIENCY.

Second, the subjects appeared unable to collude tacitly. In line with our assumption in Section 3 and consistently with the large experimental literature on communication and coordination (see e.g., Crawford 1998), actual communication was indeed critical for sustaining high prices. In all treatments, prices on average were close to the non-cooperative Bertrand prices absent communication and were systematically larger with communication

Treatment	*average price* without communication	with communication	overall
FINE			
$F = 200,\ \alpha = 0.10$	3.4	5.7	4.3
$F = 1000,\ \alpha = 0.02$	3.3	6.0	4.2
$F = 1000,\ \alpha = 0$	3.8	6.8	5.2
LENIENCY			
$F = 200,\ \alpha = 0.10$	3.5	5.7	3.9
$F = 1000,\ \alpha = 0.02$	3.5	7.2	3.8
$F = 1000,\ \alpha = 0$	3.9	7.9	4.7
L-FAIRE	3.3	4.9	4.3
Total	3.5	6.0	4.3

Table 4: **Average price with and without communication.**

(see Table 4).[16] We now turn to an in-depth discussion of our data on deterrence. We present first our main result, then discuss the results from the LENIENCY treatments. Finally, we focus on the deterrence effects in the FINE treatments and compare them with those in the LENIENCY (and the NOREPORT) treatments.

4.1 Main result

Theories of law enforcement that ignore the Trust Problem do not predict that leniency programs will deter cartel formation due to the fear of being reported. The reporting behavior in the LENIENCY treatments suggests that these theories may thereby fail to capture an important deterrence channel; the majority of subjects undercutting the agreed price in the LENIENCY treatments did indeed simultaneously report the cartel (see Table 5).

[16]These price patterns are consistent also with our results on post-conviction prices in Bigoni et al. (2012) where we noted that subjects were unable to sustain high prices after conviction unless they re-formed a cartel by communicating. Note also that the LENIENCY treatments appear to improve welfare relative to the FINE treatments by reducing prices on average. And yet the welfare effects of standard policies – with and without leniency – are ambiguous; prices on average fall in some FINE and LENIENCY treatments relative to L-FAIRE, whereas in others they increase. Explaining these price patterns was at the heart of our previous paper. In this paper we focus mainly on deterrence effects. These are more likely to apply to other forms of cooperative crimes (fraud, corruption, smuggling) than are price effects, which are specific to oligopolies.

	"secret" reports†		"public" reports‡	
Treatment	Fine	Leniency	Fine	Leniency
$\alpha = 0;\ F = 1000$	0.005	1.000	0.125	–
N. of observations	*186*	*20*	*64*	*0*
$\alpha = 0.02;\ F = 1000$	0.000	0.538	0.027	1.000
N. of observations	*127*	*13*	*37*	*3*
$\alpha = 0.10;\ F = 200$	0.000	0.577	0.197	0.500
N. of observations	*211*	*71*	*61*	*10*

† given own price deviation.

‡ given that only the opponent deviated.

Table 5: Rate of reports.

Our main result further corroborates the failure of the standard theories in explaining our experimental data, but raises also novel questions. The experimental data are consistent with the first part of the Main Hypothesis ($\mathbf{MH}_L$), but not the second part ($\mathbf{MH}_F$).

Main Result (zero expected fine) *With a zero probability of detection, a positive fine*

$\mathbf{MR}_L$: *increases deterrence under* Leniency;

$\mathbf{MR}_F$: *increases deterrence under* Fine, *albeit to a smaller extent than under* Leniency.

Result $\mathbf{MR}_L$ reflects the large drop in the rate of communication decisions in the Leniency treatment where $\alpha = 0$ and $F = 1000$ relative to L-Faire. The rate of communication decisions decreases by nearly 50 percentage points and the effect is highly significant (see Figure 2 and Table 3a). This finding suggests that the threat of being reported in the Leniency treatment may have undermined trust among the subjects, reducing their willingness to form cartels.

Let us now turn to the second observation, that also in the Fine treatment with a zero probability of detection, significant deterrence effects emerge, albeit smaller ones than in the Leniency treatment. This pattern contradicts the second part of our Main Hypothesis and suggests that deterrence channels other than those related to the PC, the ICC and the Trust Problem may be at work. Potential explanations include that: (i) subjects feared that their opponents could report cartels despite being costly, perhaps because they had misunderstood the consequences of a report, or because of "non-standard" preferences or perhaps simply by mistake; (ii) fines may have had a symbolic effect by stressing the illegal nature of cartels.

Our data do not allow us to discriminate among these potential deterrence channels. More importantly, these channels may well have been at work also in the LENIENCY treatment. Therefore the Trust Problem probably does not explain the entire difference in cartel formation between LENIENCY and L-FAIRE. Still, there is no obvious reason why any additional deterrence channels should have been more prevalent with leniency than without. In our view, the Trust Problem therefore appears to be the most likely explanation for the large drop in communication rates in the LENIENCY relative to the FINE treatment where $\alpha = 0$ and $F = 1000$ (25.8 percentage points, significant at the 1 percent level).[17]

4.2 More on deterrence with leniency

The potentially important policy implication of our main result $\mathbf{MR}_L$ is that leniency programs may have a non-trivial deterrence effect even when no resources are devoted to crime detection. And, if fines are more efficient in deterring crime than are costly audits and dawn raids, it could be optimal to divert most enforcement resources to other tasks than crime detection (for example, to the prosecution of reported cartels). To shed more light on this issue, we now investigate the effects of changes in the probability of detection and in the fine on the subjects' propensity to form cartels.

Result $\mathbf{R1}_L$: *An increase in the expected fine only marginally increases deterrence under* LENIENCY.

Our experimental data are only weakly consistent with Hypothesis $\mathbf{H1}_L$. The comparison between the LENIENCY treatments with the same large fine ($F = 1000$) but different probabilities of detection ($\alpha = 0$ and $\alpha = 0.02$) indicates that an increase in the expected fine through an increase in the probability of detection only marginally increases deterrence. The rate of communication attempts falls by 2.9 percentage points and the effect is significant at the 10% level only (see Figure 2 and Table 3b). The relatively small increase in deterrence induced by the increase in α suggests that the tightening of the PC and the ICC plays a minor role when leniency programs are in place. The worsening of the Trust

[17] The p-value is obtained from a logit regression with three-level random effects. The dependent variable is the binary decision whether to communicate or not when subjects would not otherwise be liable for collusion. The main independent variable is a dummy taking value one for the LENIENCY treatment, and zero for the FINE treatment. Standard errors are robust for heteroskedasticity. Regression results are available from the authors upon request.

Problem, linked to a large fine F and the risk of being betrayed and reported, seems to be a more important channel through which leniency generates deterrence.

The comparison between the LENIENCY treatments with the same expected fine but different mixes of α and F (i.e. the treatments where $(\alpha, F) = (0.02, 1000)$ and $(\alpha, F) = (0.1, 200)$) appears to corroborate this interpretation.

Result $\mathbf{R2}_L$: *Under* LENIENCY *an increase in the fine F, compensated by a reduction in the detection probability α so as to keep αF constant, significantly increases deterrence.*

Result $\mathbf{R2}_L$ is consistent with Hypothesis $\mathbf{H2}_L$: the large reduction in the fine from 1000 to 200 substantially reduces deterrence, despite the simultaneous increase in the probability of detection. The rate of communication attempts increases by 9.3 percentage points and the effect is significant at the 1% level (see Figure 2 and Table 3c). The fine thus appears to be the most efficient deterrence tool with leniency.

4.3 More on deterrence under traditional law enforcement

This section focuses on the FINE treatments. Our purpose is to identify channels through which deterrence works absent leniency and to contrast these channels with those at work under leniency. Our first finding sheds light on the role of the expected fine in law enforcement environments without leniency.

Result $\mathbf{R1}_F$: *An increase in the expected fine αF induced by an increase in the probability of detection α increases deterrence significantly in* FINE*; this effect is larger than in* LENIENCY*.*

Result $\mathbf{R1}_F$ is consistent only with the first part of Hypothesis $\mathbf{H1}_F$. It reflects the substantial decrease in the rate of communication decisions when we compare the FINE treatment where $\alpha = 0.02$ and $F = 1000$ with the same treatment where $\alpha = 0$ and $F = 1000$. The rate of communication decisions decreases by 16 percentage points and the effect is highly significant (see Figure 2 and Table 3a). Without leniency, deterrence thus increases with *the expected fine αF* as predicted by classic law enforcement theory (crime becomes less profitable in expectation and the PC is tightened).

Our data, however, are not consistent with the second part of Hypothesis $\mathbf{H1}_F$, as the deterrence effect is stronger in FINE than in LENIENCY (see Result $\mathbf{R1}_L$). The increase in the expected fine was driven by an increase in α keeping F constant, suggesting that subjects were more concerned with this change in Fine than in Leniency. A possible explanation is that in Leniency the risk of being cheated and reported is more salient, limiting the impact of changes in α. This explanation would be consistent with our general idea that leniency programs may be altering the mechanism through which deterrence takes place in favor of the risk of being betrayed, the size of the fine, and the impact on the demand for trust.

Our next finding suggests that low fines may have perverse effects.

Result $\mathbf{R2}_F$: *An increase in the fine F compensated by a reduction in the probability of detection α, so as to keep the expected fine αF constant, significantly increases deterrence in* Fine*; this effect is larger than in* Leniency.

The first part of Result $\mathbf{R2}_F$ is in line with Hypothesis $\mathbf{H2}_F$, and reflects the sharp increase in the rate of communication decisions in the Fine treatment where $\alpha = 0.1$ and $F = 200$ relative to the treatment where $\alpha = 0.02$ and $F = 1000$. The rate of communication decisions increases by 21.2 percentage points and the effect is highly significant (see Figure 2 and Table 3c). The second part of the result is instead inconsistent with Hypothesis $\mathbf{H2}_F$, which predicted a larger effect in Leniency (Result $\mathbf{R2}_L$).

The strength of the reduction in deterrence under Fine is also puzzling, because the dynamic effect driving it is subtle. An alternative explanation is that the subjects may have perceived the use of costly reports as a credible threat against deviations only when the fine was moderate and equal to 200. The cost of self-reporting when the fine was high and equal to 1000 relative to the cost imposed by a cheating opponent - at most 160[18] - may have been perceived as too high for reporting to be considered a credible threat without leniency. A first piece of evidence consistent with this explanation is that public reports were used more often to punish cheating opponents in the Fine treatment with the low fine than in the Fine treatment with the large fine (Table 5).

To further investigate this potential explanation, we ran the additional NoReport treatment, a Fine treatment with $\alpha = 0.1$ and $F = 200$, where reporting was impossible by design. Removing the possibility to report substantially increased deterrence; communication rates dropped from 59% to 31.8% and the effect was highly significant (see Table 6). This suggests that the possibility to report was indeed perceived as an additional credible (albeit costly) punishment tool against defections when the fine was low enough, which increased cartel formation.

[18] This number equals the cost imposed on the cheated party if the monopoly price is the agreed price and the cheating subject undercuts optimally (see Table 1).

Table 6: Deterrence in the 'NoReport' treatment

	$\alpha = 0.1, F = 200$ vs. NoReport	$\alpha = 0.02, F = 1000$ vs. NoReport
NoReport	-0.410***	-0.149**
	(0.026)	(0.064)
Log-Likelihood	-681.425	-591.044
N	1218	1140

Note: Results from logit regressions with three-level random effects. The dependent variable is the binary decision whether to communicate or not when subjects would not otherwise be liable for collusion. The main independent variable is a dummy taking value one for the treatment of interest, and zero for the reference treatment. Standard errors are robust for heteroskedasticity. The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

5 Conclusion

Our laboratory experiment explores how the fine and the probability of exogenous detection by a law enforcement agency, affect cartels and analogous cooperative crimes in which wrongdoers are exposed to the risk of being betrayed and denounced by partner wrongdoers. The results suggest that leniency policies restricted to the first party to report spontaneously, without being subject to an investigation, can produce a considerable increase in deterrence. The deterrence appears to be driven mainly by an increased fear of being betrayed and reported. By increasing both the incentive to betray and the cost of being betrayed by a partner, leniency seems to generate a higher demand for trust among criminals, hence less crime for any given level of trust. Then, a high absolute level of the fine is the most important determinant of deterrence, effective even if there is no risk of detection by the law enforcement agency without a report. Traditional deterrence channels appear more important in the absence of leniency policies: the probability of detection and the expected fines have a stronger influence on behavior. Low fines are not advisable, however, because besides having limited deterrence effects, these may be used strategically as punishments to stabilize rather than deter cartels.

To the extent that our results apply to real world settings, they have important policy implications. They suggest that the benefits of tough sanctions may have been underestimated in the case of cartels and similar crimes. When reporting is an option, tough sanctions have a direct effect on deterrence, independent of their well-known effect on the level of the 'Beckerian' expected sanction. This effect is particularly strong when well-designed leniency policies make betrayal and self-reporting highly attractive and likely. The smaller deterrence effect we still observe when α equals zero in the absence of leniency remains difficult to interpret within our theoretical framework, calling for additional theoretical and experimental work. Our results also highlight the high complementarity between modern leniency policies and traditional sanctions. They also suggest that recent concerns that competition authorities are being overburdened by an excess of leniency applications should be addressed by increasing fine levels.

Interesting avenues for future research include robustness checks, such as changes in the parametrization and the framing of the experiment (although recent work by Krajčová and Ortmann 2008 suggests that our results should be robust); understanding whether and how less structured forms of communications influence our findings (e.g. Harrington et al. 2013); and studying whether the structure of criminal organizations reacts and adapts to the introduction of novel law enforcement methods, a possibility suggested by recent theoretical work (e.g. Garoupa 2007, and Baccara and Bar-Isaac 2008). It would also be interesting to attempt to identify and quantify experimentally the possible role played by 'betrayal aversion' (Bohnet et al. 2008). An additional perceived cost of being betrayed by a peer relative to that of being discovered and fined by a more neutral 'law enforcement agency', may indeed have contributed to the strong deterrence effect of leniency in our experiment.

A Appendix

A.1 Existence of collusive equilibria

Our experimental design implements a discounted repeated (uncertain horizon) price game embedded in different antitrust law enforcement institutions. Experimental evidence shows that communication helps subjects coordinating on cooperation (see Crawford 1998). In line with these findings, the simple analysis below presumes communication (i.e., cartel formation) to be a prerequisite for successful cooperation (collusion). Its purpose is to reach sensible testable hypotheses, not to derive the whole equilibrium set.

For simplicity we assume throughout this section that the subjects must communicate once to establish successful collusion, but are able to collude tacitly following a detection by the competition authority.[19] Cartel members thus risk to be fined once on the collusive path. Given a per period probability of detection α, a fine F and a discount factor δ (the probability of being re-matched with the same competitor in the next period), the per period expected fine is given by αF and the expected fine payment by $EF = \alpha F + (1-\alpha)\,\delta EF$, or equivalently

$$EF = \frac{\alpha F}{1-(1-\alpha)\,\delta}. \tag{EFine}$$

The Participation Constraint (PC) The PC states that the gains from collusion should be larger than the expected cost. Assuming that across periods and treatments, cartels charge the same price on the collusive path, the PCs in L-Faire and in the policy treatments can then be expressed as

$$\frac{\pi^c-\pi^b}{1-\delta} \geq 0 \text{ and } \frac{\pi^c-\pi^b}{1-\delta} \geq EF, \tag{PC}$$

where π^b denotes the profits in the competitive Bertrand equilibrium and π^c the profits on the collusive path. Given α and F, the PCs are the same in Fine and Leniency treatments, and are tighter in the policy treatments than in L-Faire due to the expected fine payment, EF.

The Incentive Compatibility Constraints (ICC) The ICC states that sticking to an agreement is preferred over a unilateral price deviation followed by a punishment. Pun-

[19]This assumption implies that the subsequent expressions are relevant mainly for decisions to form cartels given that subjects are not currently members of a successful cartel.

ishments are assumed to take the standard form of a price war.[20] In addition, cartels are assumed not to re-form once they have been dismantled following a price deviation. This assumption implies that the present value in the beginning of the punishment phase (net of potential fine payments), V^p, can be generated by optimal symmetric punishments (given the above stated assumptions). Alternatively, V^p can be viewed as resulting from some weaker form of punishment, which by assumption is the same across treatments.

All else equal, the ICCs can then be expressed as

$$\frac{\pi^c}{1-\delta} \geq \pi^d + \delta V^p, \qquad \text{(ICC-L-Faire)}$$

$$\frac{\pi^c}{1-\delta} - EF \geq \pi^d - EF + \delta V^p, \qquad \text{(ICC-Fine)}$$

$$\frac{\pi^c}{1-\delta} - EF \geq \pi^d + \delta V^p, \qquad \text{(ICC-Leniency)}$$

where π^d denotes the deviation profit. Following a deviation, a player risks to be fined in Fine only, since an optimal deviation in Leniency is combined with a simultaneous secret report. After reporting the defecting player is protected against the fine, not only because the risk of being detected by the competition authority is eliminated, but also because the competitor cannot use the public report to punish. Note in (ICC-Fine) that EF appears on both sides of the inequality, since dismantled cartels are assumed not to re-form, either on the collusive path or on the punishment path. Thus the ICCs are (i) the same in L-Faire and Fine treatments and (ii) all else equal, tighter in Leniency than in Fine treatments (since a deviation combined with a secret report provides protection against the fine, EF).

Finally, collusive equilibria exist if the PC and the ICC hold. Note from the PCs and ICCs that a collusive price is sustainable in all treatments if it is sustainable in the Leniency treatment with the largest EF. Thus, let $\alpha = 0.02$ and $F = 1000$ (as in the treatment with the largest EF) and consider a collusive equilibrium sustained through grim trigger strategies where the collusive price equals 9. The rematching procedure implies for risk neutral subjects that $\delta = 0.85$. Moreover, $\pi^b = 100$, $\pi^c = 180$ and $\pi^d = 296$. Then $EF = 119.76$ and $V^p = \pi^b / (1 - \delta) = 666.67$ so that both (PC) and (ICC-Leniency)

[20] We also assume that reports are not used on the punishment path. Public reports as punishments against a price deviation can however be credible in the Fine treatments. In fact, we show in Bigoni et al. (2009), a working paper version of Bigoni et al. (2012), that optimal punishments involve public reports. Subjects nevertheless appear not to use such strong punishments (see Bigoni et al. 2012 for details) and therefore we disregard these when stating our theoretical predictions.

hold with strict inequality. Thus the joint profit-maximizing price is sustainable in all treatments.

A.2 The determinants of the minimum level of trust

This Appendix offers a formal comparison of the *minimum level of trust* across treatments.[21] We assume symmetric punishment strategies. That is, the payoff on the punishment path is given by V^p regardless of whether one or both subjects defect, and is the same for defecting and cheated subjects. We get

$$V^{ss}_{L-Faire} - V^{ds}_{L-Faire} = \frac{\pi^c}{1-\delta} - \left(\pi^{d1} + \delta V^p\right), \tag{2}$$

$$V^{ss}_{Fine} - V^{ds}_{Fine} = \frac{\pi^c}{1-\delta} - EF - \left(\pi^{d1} - EF + \delta V^p\right), \tag{3}$$

$$V^{ss}_{Len} - V^{ds}_{Len} = \frac{\pi^c}{1-\delta} - EF - \left(\pi^{d1} + \delta V^p\right), \tag{4}$$

where π^{d1} denotes the one period payoff from a unilateral price deviation, and

$$V^{dd}_{L-Faire} - V^{sd}_{L-Faire} = \pi^{d2} + \delta V^p - (\pi^s + \delta V^p), \tag{5}$$

$$V^{dd}_{Fine} - V^{sd}_{Fine} = \pi^{d2} - EF + \delta V^p - (\pi^s - EF + \delta V^p), \tag{6}$$

$$V^{dd}_{Len} - V^{sd}_{Len} = \pi^{d2} - \frac{F}{2} + \delta V^p - (\pi^s - F + \delta V^p), \tag{7}$$

where π^{d2} denotes the deviation payoff if both players undercut and π^s the "sucker's payoff" following a unilateral deviation by the opponent. It can be easily verified that $V^{ss}_{L-Faire} - V^{ds}_{L-Faire} = V^{ss}_{Fine} - V^{ds}_{Fine} > V^{ss}_{Len} - V^{ds}_{Len}$ and $V^{dd}_{L-Faire} - V^{sd}_{L-Faire} = V^{dd}_{Fine} - V^{sd}_{Fine} < V^{dd}_{Len} - V^{sd}_{Len}$. Hence, $\beta_{L-Faire} = \beta_{Fine} < \beta_{Len}$.

Note that the ICC (as defined in A.1) affects the demand for trust through $V^{ss}_K - V^{ds}_K$: the basin of attraction of sticking to the cooperative strategy expands as the ICC gets looser (since β_K decreases as $V^{ss}_K - V^{ds}_K$ increases). Yet there is also a notable difference between the expressions for $V^{ss}_K - V^{ds}_K$ and the ICCs: π^{d1} replaces π^d in $V^{ss}_K - V^{ds}_K$. This difference stems from the fact that the size of an optimal price deviation must be (weakly) larger if the defecting subject believes that the opponent also undercuts with some positive probability. As a result, the payoff following a unilateral deviation ranges from the payoff resulting from

[21] The comparisons between treatments do not depend on the exact deviation strategy considered. It is however important to assume that subjects undercut by the same amount (and attempt to collude on the same price) across treatments.

a "safe" Bertand price (when the opponent chooses the collusive price) and the payoff from an optimal unilateral defection, π^d. Hence $\pi^b < \pi^{d1} \leq \pi^d$ and $\pi^b \leq \pi^{d2} < \pi^{d1}$.[22]

Note also that β_K increases with $V_K^{dd} - V_K^{sd}$: the basin of attraction of sticking to the cooperative strategy shrinks as $V_K^{dd} - V_K^{sd}$ increases (i.e., since the gains from defecting relative to sticking to the agreement, given that the opponent is not trustworthy, increase).

A.3 Increased expected fine

This appendix motivates Hypothesis 2. A change in αF affects the PC, the ICC and β_K either through its impact on the expected fine payment, EF, or through its effect on the size of the absolute fine, F. Given the combinations of α and F considered in our treatments, however, both EF and F increase whenever αF increases. Therefore an increase in αF tightens the PC under Fine (since EF increases) but has no effect on the ICC or on β_{Fine} (as EF cancels out in (ICC-Fine) as well as in (3) and (6)). Similarly, an increase in αF tightens the PC under Leniency. Under Leniency, however, an increase in αF also tightens the ICC (through an increase in EF) and increases β_{Len} (since $V_{Len}^{ss} - V_{Len}^{ds}$ decreases as EF increases and since $V_{Len}^{dd} - V_{Len}^{sd}$ increases as F increases).

A.4 Constant expected fine

This appendix motivates Hypothesis 3. An increased F compensated by a reduced α so as to keep αF constant increases EF. Therefore the PC is tightened under Fine while both the ICC and β_{Fine} are unaffected by the change (as EF does not enter the relevant expressions). Similarly, such a change tightens the PC under Leniency. In addition, the increase in EF also tightens the ICC under Leniency and thereby also increases β_{Len}. The effect on β_{Len} is exacerbated since $V_{Len}^{dd} - V_{Len}^{sd}$ increases in F.

A.5 Zero expected fine

This appendix motivates Hypothesis 4. Based on the PCs and the ICCs, neither Fine nor Leniency should have a deterrence effect relative to L-Faire when the per period expected fine is 0. Note also that Fine does not require more trust than L-Faire as $\beta_{L-Faire} = \beta_{Fine}$. Therefore only Leniency should have a deterrence effect when the per

[22] The gains from a unilateral deviation are thus (weakly) lower than those indicated by the ICCs, since the defecting subject may find it profitable to undercut the agreed price by a larger amount. Conditional on all other assumptions, however, this fact does not affect the ranking of the ICCs across treatments.

period expected fine is 0 (and $F > 0$) as it requires more trust in the sense that $\beta_{Fine} < \beta_{Len}$ (since $V_{Fine}^{dd} - V_{Fine}^{sd} < V_{Len}^{dd} - V_{Len}^{sd}$).

A.6 Robustness

Two assumptions underlying the above analysis are worth emphasizing. First, subjects collude tacitly following an exogenous detection on the collusive path and, second, cartels are not re-formed on the punishment path. Provided the cartel is not reported following a deviation (as it is under LENIENCY) the expected fine payment, EF, is therefore the same on the collusive and the punishment paths.

These assumptions are not innocuous. Suppose that successful collusion requires cartels to be re–formed on the collusive path, even after an exogenous detection by the competition authority. All else equal, this alternative assumption introduces additional deterrence channels. Under FINE, the ICC is tightened (and thereby β_{Fine} also increases) since expected fine payments on the collusive path, given by $EF^c = \alpha F/(1-\delta)$, are larger than the expected fine payment, EF, on the punishment path. The ICC is also tightened under LENIENCY, as the secret report (associated with a price deviation) provides protection against the larger expected fine payments, EF^c. Most hypotheses nevertheless remain unchanged. The exception is Hypothesis 3 as an increase in F, compensated by a fall in α so as to keep the per period expected fine constant, leaves EF^c (but not EF) unchanged. Thereby such a change in the mix of α and F should have a deterrence effect only under LENIENCY, since the increase in F per se worsens the sucker's payoff and thereby increases the demand for trust.

Consider next the assumption that cartels are not re–formed on the punishment path. Presumably it holds if the punishment is carried out through a grim trigger strategy. By contrast, a stick and carrot type of punishment probably requires cartels to be formed during the 'carrot' phase, and possibly also during the 'stick' phase. Relaxing the assumption would alter the analysis in two ways. First, it would strengthen the punishment in the policy treatments (though not in L-FAIRE) as subjects run the risk of being fined also on the punishment path. Second, it would affect the scope for punishing defectors, particularly in the LENIENCY treatments because the deviation incentives (from the punishment path) would be magnified by the possibility to report. A formal treatment of these complicating factors is beyond the scope of this experimental paper.

References

Apesteguia, J., M. Dufwenberg, and R. Selten (2007). Blowing the Whistle. *Economic Theory 31*(1), 143–166.

Baccara, M. and H. Bar-Isaac (2008). How to Organize Crime. *Review of Economic Studies 75*(4), 1039–1067.

Becker, G. (1968). Crime and Punishment: An Economic Approach. *The Journal of Political Economy 76*(2), 169–217.

Berg, J., J. Dickhaut, and K. McCabe (1995). Trust, Reciprocity, and Social History. *Games and Economic Behavior 10*(1), 122–142.

Bigoni, M., S. O. Fridolfsson, C. Le Coq, and G. Spagnolo (2009). Fines, Leniency and Rewards in Antitrust: an Experiment. CEPR Discussion Papers 7417.

Bigoni, M., S.-O. Fridolfsson, C. Le Coq, and G. Spagnolo (2012). Fines, Leniency, and Rewards in Antitrust. *The RAND Journal of Economics 43*(2), 368–390.

Blonski, M., P. Ockenfels, and G. Spagnolo (2011). Equilibrium selection in the repeated prisoner's dilemma: Axiomatic approach and experimental evidence. *American Economic Journal: Microeconomics 3*(3), 164–192.

Blonski, M. and G. Spagnolo (Forthcoming). Prisoners' Other Dilemma. *International Journal of Game Theory*.

Bohnet, I., F. Greig, B. Herrmann, and R. Zeckhauser (2008). Betrayal Aversion: Evidence from Brazil, China, Oman, Switzerland, Turkey, and the United States. *American Economic Review 98*(1), 294–310.

Brenner, S. (2009). An Empirical Study of the European Corporate Leniency Program. *International Journal of Industrial Organization 27*(6), 639–645.

Chang, M. H. and J. E. Harrington (2010). The Impact of a Corporate Leniency Program on Antitrust Enforcement and Cartelization. Mimeo.

Charness, G. and M. Dufwenberg (2006). Promises and Partnership. *Econometrica 74*(6), 1579–1601.

Crawford, V. (1998). A Survey of Experiments on Communication via Cheap Talk. *Journal of Economic Theory 78*(2), 286–298.

Dal Bó, P. and G. Fréchette (2011). The Evolution of Cooperation in Infinitely Repeated Games: Experimental Evidence. *American Economic Review 101*(1), 411–429.

Engelmann, D. and W. Müller (2011). Collusion through Price Ceilings? In Search of a Focal-point Effect. *Journal of Economic Behavior & Organization 79*(3), 291 – 302.

Falk, A. and M. Kosfeld (2006). The Hidden Costs of Control. *The American Economic Review 96*(5), 1611–1630.

Fehr, E. (2009). On the Economics and Biology of Trust. *Journal of the European Economic Association 7*(2-3), 235–266.

Fehr, E. and J. List (2004). The Hidden Costs and Returns Of Incentives – Trust and Trustworthiness Among CEOs. *Journal of the European Economic Association 2*(5), 743–771.

Fischbacher, U. (2007). z-Tree: Zurich Toolbox for Ready-made Economic Experiments. *Experimental Economics 10*(2), 171–178.

Gambetta, D. (2000). Can We Trust Trust? In D. Gambetta (Ed.), *Trust: Making and Breaking Cooperative Relations*, pp. 213–237. Oxford University Press.

Garoupa, N. (2007). Optimal law enforcement and criminal organization. *Journal of Economic Behavior & Organization 63*(3), 461–474.

Guiso, L., P. Sapienza, and L. Zingales (2008). Trusting the stock market. *The Journal of Finance 63*(6), 2557–2600.

Hamaguchi, Y., T. Ishikawa, M. Ishimoto, Y. Kimura, and T. Tanno (2007). An Experimental Study of Procurement Auctions with Leniency Programs. Competition Policy Research Center Discussion Paper Series, CRDP-24-E.

Hamaguchi, Y., T. Kawagoe, and A. Shibata (2009). Group Size Effects on Cartel Formation and the Enforcement Power of Leniency Programs. *International Journal of Industrial Organization 27*(2), 145–165.

Harrington, J. E. (2013). Corporate Leniency Programs when Firms have Private Information: The Push of Prosecution and the Pull of Pre-emption. *The Journal of Industrial Economics 61*(1), 1–27.

Harrington, J. E., R. Hernan-Gonzalez, and P. Kujal (2013). The relative efficacy of price announcements and express communication for collusion: Experimental findings. Mimeo.

Hinloopen, J. and A. Soetevent (2008). Laboratory Evidence on the Effectiveness of Corporate Leniency Programs. *The RAND Journal of Economics 39*(2), 607–616.

Holt, C. (1995). Industrial Organization: A Survey of Laboratory Research. In J. Kagel and A. Roth (Eds.), *The Handbook of Experimental Economics*, pp. 349–443. Princeton University Press.

Huck, S., H.-T. Normann, and J. Oechssler (1999). Learning in Cournot Oligopoly – An Experiment. *Economic Journal 109*(454), C80–95.

Huck, S., H.-T. Normann, and J. Oechssler (2004). Two Are Few and Four Are Many: Number Effects in Experimental Oligopolies. *Journal of Economic Behavior & Organization 53*(4), 435–446.

Kaplow, L. and S. Shavell (1994). Optimal Law Enforcement with Self-Reporting of Behavior. *The Journal of Political Economy 102*(3), 583–606.

Knack, S. and P. Zak (2003). Building Trust: Public Policy, Interpersonal Trust, and Economic Development. *Supreme Court Economic Review 10*, 91–107.

Kosfeld, M., M. Heinrichs, P. Zak, U. Fischbacher, and E. Fehr (2005). Oxytocin Increases Trust in Humans. *Nature 435*(7042), 673–676.

Krajčová, J. and A. Ortmann (2008). Testing Leniency Programs Experimentally: The Impact of "Natural" Framing. CERGE-EI Working Paper.

Leslie, C. (2004). Trust, Distrust, and Antitrust. *Texas Law Review 82*(3), 515–680.

Miller, N. (2009). Strategic Leniency and Cartel Enforcement. *American Economic Review 99*(3), 750–768.

Motta, M. and M. Polo (2003). Leniency Programs and Cartel Prosecution. *International Journal of Industrial Organization 21*(3), 347–379.

Myerson, R. B. (1991). *Game Theory: Analysis of Conflict*. Harvard University Press.

Offerman, T., J. Potters, and J. Sonnemans (2002). Imitation and Belief Learning in an Oligopoly Experiment. *Review of Economic Studies 69*(4), 973–97.

Potters, J. (2009). Transparency about past, present and future conduct. Experimental evidence on the impact on competitiveness. In J. Hinloopen and H. T. Normann (Eds.), *Experiments and Competition Policy*. Cambridge University Press.

Rey, P. (2003). Toward a Theory of Competition Policy. In M. Dewatripont, L. Hansen, and S. Turnovsky (Eds.), *Advances in Economics and Econometrics: Theory and Applications: Eighth World Congress*, Chapter 3, pp. 82–132. Cambridge University Press.

Riley, A. (2007). Developing Criminal Cartel Law: Dealing with the Growing Pains. *Competition Law Review 4*(1), 1–6.

Sapienza, P., A. Toldra-Simats, and L. Zingales (2013). Understanding trust. *The Economic Journal 123*(573), 1313–1332.

Schildberg-Hörisch, H. and C. Strassmair (2012). An experimental test of the deterrence hypothesis. *Journal of Law, Economics, and Organization 28*(3), 447–459.

Skrondal, A. and S. Rabe-Hesketh (2004). *Generalized Latent Variable Modeling: multilevel, longitudinal, and structural equation models*. CRC Press.

Spagnolo, G. (2004). Divide et Impera: Optimal Leniency Programs. CEPR Discussion Paper No. 4840.

Spagnolo, G. (2008). Leniency and Whistleblowers in Antitrust. In P. Buccirossi (Ed.), *Handbook of Antitrust Economics*. MIT Press, Cambridge, MA.

Stigler, G. J. (1964). A Theory of Oligopoly. *The Journal of Political Economy 72*(1), 44–61.

Von Lampe, K. and P. Johansen (2004). Organized Crime and Trust: On the Conceptualization and Empirical Relevance of Trust in the Context of Criminal Networks. *Global Crime 6*(2), 159–184.

B Material intended for an online Appendix

B.1 Experimental Sessions

The table below provides additional details about each session: when and where they were conducted, the number of subjects in each session, and the number of periods and matches.

Treatment	**date**	**n. of subjects**	**n. of periods**	**n. of matches**
Fine	31/05/2007	32	26	6
	04/06/2007	32	27	2
	14/12/2007	32	25	3
Leniency	04/06/2007	32	25	2
	05/06/2007	32	26	3
	08/06/2007	32	22	3
L-Faire	30/05/2007	32	23	4
No-Report	14/12/2007	32	27	5

Table B.1: **Treatments**

B.2 Empirical methodology

A critical point in our analysis is how to control for repeated observations of the same subject or the same duopoly, when testing the significance of observed differences across treatments. Given the re–matching procedure, we need to account for correlations between observations from the same individual and between observations from different individuals belonging to the same duopoly. To this end, we adopted multilevel random effect models.

The random effects at the subject and duopoly levels are not nested, since subjects participated in more than one duopoly. This makes it difficult to estimate a model including a random effect both at the duopoly and at the subject levels. To overcome this difficulty, we hypothesize the presence of a random effect for every subject within any particular match (which accounts for correlations between observations from the same match), nested with a random effect for every subject across different matches.

We model the binary response $CommDec_{nms}$ by a random intercept three-levels logit model of the following form:

$$(CommDec_{nms}|\mathbf{x}_{nms}, \eta^{(2)}_{ms}, \eta^{(3)}_{s}) \sim \text{binomial}(1, \pi_{nms})$$
$$logit(\pi_{nms}) = \beta\mathbf{x}_{nms} + \eta^{(2)}_{ms} + \eta^{(3)}_{s} = \nu_{nms}$$

where $\pi_{nms} = Pr(CommDec_{nms}|\mathbf{x}_{nms}, \eta^{(2)}_{ms}, \eta^{(3)}_{s})$. n, m and s are indices for measurement occasions, subjects in matches, and subjects across matches, respectively. $CommDec_{nms}$ represents the n-th communication decision of subject s in match m. $\mathbf{x}_{nms}$ is a vector of explanatory variables (including the constant), with fixed regression coefficients β. $\eta^{(2)}_{ms}$ represents the random intercept for subject s in match m (second level), and $\eta^{(3)}_{s}$ represents the random intercept for subject s (third level). Random intercepts are assumed to be independently normally distributed, with a variance that is estimated through our regression. To estimate our model we use the GLLAMM commands in Stata.[23]

[23]see Skrondal and Rabe-Hesketh (2004) and http://www.gllamm.org

B.3 Instructions for Leniency

Welcome to this experiment about decision making in a market. The experiment is expected to last for about 1 hour and 45 minutes. You will be paid a minimum of €7 for your participation. On top of that you can earn more than €30 if you make good decisions. We will first read the instructions aloud. Then you will have time to read them on your own. If you then have questions, raise your hand and you will be helped privately.

In summary, the situation you will face is the following. You and one other participant referred to as your competitor produce similar goods and sell them in a common market. As in most markets, the higher the price you charge, the more you earn on each sold good, but the fewer goods you sell. And, as in many markets, the lower the price charged by your competitor, the more customers he or she will take away from you and the less you will sell and earn. It is possible, however, to form a cartel with your competitor, that is, you will have the possibility to communicate and try to agree on prices at which to sell the goods. In reality, cartels are illegal and if the government discovers the cartel, cartel members are fined. In addition members of a cartel can always report it to the government. The same happens in this experiment. If you communicate to discuss prices, even if both of you do not report, there is still a chance that the 'government' discovers it and if this happens, you will have to pay a 'fine'. If you report, and if you are the only one to report, you will not pay any fine but your competitor will pay the full fine. Conversely, if only your competitor reports the cartel, you will pay the full fine and your competitor will not pay any fine. If instead both of you report the cartel you will both pay 50% of the fine.

Timing of the experiment In this experiment you will be asked to make decisions in several periods. You will be paired with another participant for a sequence of periods. Such a sequence of periods is referred to as a match. You will never know with whom you have been matched in this experiment.

The length of a match is random. After each period, there is a probability of 85% that the match will continue for at least another period. So, for instance, if you have been paired with the same competitor for 2 periods, the probability that you will be paired with him or her a third period is 85%. If you have been paired with the same competitor for 9 periods, the probability that you will be paired with him or her a tenth period is also 85%.

Once a match ends, you will be paired with another participant for a new match, unless 20 periods or more have passed. In this case the experiment ends. So, for instance, if 19 periods have passed, with a probability of 15% you are re-matched, that is you are paired with another participant. If 21 periods have passed, with a probability of 15% the experiment ends.

When you are re-matched you cannot be fined anymore for a cartel formed in your previous match with your previous competitor.

The experimental session is expected to last for about 1 hour and 45 minutes but its actual duration is uncertain; that depends on the realization of probabilities. For this reason, we will end the experimental session if it lasts more than 2 hours and 30 minutes.

Before the experiment starts, there will be 5 trial periods during which you will be paired with the same competitor. These trial periods will not affect your earnings. When the experiment starts, you will be paired with a new competitor.

Prices and Profits In each period you choose the price of your product. Your price as well as the price chosen by your competitor determines the quantity that you will sell. The higher your price, the more you earn on each sold good, but the fewer goods you sell. Therefore your price has two opposing effects on your profit. On the one hand, an increase in your price may increase your profit, since each good that you sell will earn you more money. On the other hand, an increase in your price may decrease your profit, since you will sell less. Furthermore, the higher the price of your competitor, the more you will sell. As a result, your profits increase if your competitor chooses a higher price.

To make things easy, we have constructed a profit table. This table is added to the instructions. Have a look at this table now. Your own prices are indicated next to the rows and the prices of your competitor are indicated above the columns. If, for example, your competitor's price is 5 and your price is 4, then you first move to the right until you find the column with 5 above it, and then you move down until you reach the row which has 4 on the left of it. You can read that your profit is 160 points in that case.

Your competitor has received an identical table. Therefore you can also use the table to learn your competitor's profit by inverting your roles. That is, read the price of your competitor next to the rows and your price above the columns. In the previous example where your price is equal to 4 and your competitor's price is equal to 5, it follows that your competitor's profit is 100 points.

Note that if your and your competitor's prices are equal, then your profits are also equal and are indicated in one of the cells along the table's diagonal. For example, if your price and the price of your competitor are equal to 1, then your profit and the profit of your competitor is equal to 38 points. If both you and your competitor increase your price by 1 point to 2, then your profit and the profit of your competitor becomes equal to 71.

Note also that if your competitor's price is sufficiently low relative to your price, then your profit is equal to 0. The reason is that no consumer buys your good, since it is too expensive relative to your competitor's good.

Fines In every period, you and your competitor will be given the opportunity to communicate and discuss prices. If both of you agree to communicate, you will be considered to have formed a cartel, and then you might have to pay a fine F. This fine is given by:

$$F = 200 \text{ points.}$$

You can be fined in two ways. First, you and your competitor will have the opportunity to report the cartel. If you are the only one to report the cartel, you will not pay any fine but your competitor will pay the full fine, that is 200 points. Conversely, if only your competitor reports the cartel and you do not, then you will have to pay the full fine equal to 200 points and your competitor will not pay any fine. Finally, if both of you report the cartel, you will both pay 50% of the fine, that is 100 points.

Second, if neither you nor your competitor reports the cartel, the government discovers it with the following probability.

$$\text{Probability of detection} = 10\%.$$

Note that you will run the risk of paying a fine as long as the cartel has not yet been discovered or reported. Thus you may pay a fine in a period even if no communication takes place in that period. This happens if you had a meeting in some previous period which has not yet been discovered or reported.

Once a cartel is discovered or reported, you do not anymore run the risk of paying a fine in future periods, unless you and your competitor agree to communicate again.

Earnings The number of points you earn in a period will be equal to your profit minus an eventual fine. Note that because of the fine, your earnings may be negative in some periods. Your cumulated earnings, however, will never be allowed to become negative.

You will receive an initial endowment of 1000 points and, as the experiment proceeds, your and your competitor's decisions will determine your cumulated earnings. Note that 100 points are equal to €0.50. Your cumulated earnings will be privately paid to you in cash at the end of the session.

Decision making in a period Next we describe in more detail how you make decisions in each period. A period is divided into 7 steps. Some steps will inform you about decisions that you and your competitor have made. In the other steps you and your competitor will have to make decisions. In these steps, there will be a counter indicating how many seconds are left before the experiment proceeds to the next step. If you fail to make a decision within the time limit, the computer will make a decision for you.

Step 1: Pairing information and price communication decision Every period starts by informing you whether or not you will play against the same competitor as in the previous period. Remember that if you are paired with a new competitor, you cannot be fined anymore for cartels that you formed with your previous competitors. In this step you will also be asked if you want to communicate with your competitor to discuss prices. A communication screen will open only if BOTH you and your competitor choose the ”YES” button within 15 seconds. Otherwise you will have to wait for an additional 30 seconds until pricing decisions starts in Step 3.

Step 2: Price communication After the communication screen has opened, you can "discuss" prices by choosing a price out of the range {0, 1, 2, . . . , 12}. In this way you can indicate to your competitor the minimum price that you find acceptable for both of you. When both of you have chosen a price, these two prices are displayed on the computer screen. You can then choose a new price but now this price should be greater or equal to the smaller of the two previously chosen prices. This procedure is repeated until 30 seconds have passed. The screen then displays the smaller of the two last chosen prices, which is referred to as the agreed price. Note, however, that in the next step, neither you nor your competitor is forced to choose the agreed price.

Step 3: Pricing decision You and your competitor must choose one of the following prices: 0, 1, 2, . . . , 12. When you choose your price, your competitor will not observe your choice nor will you observe his or her price choice. This information is only revealed in Step 5. The experiment proceeds after 30 seconds have passed. If you fail to choose a price within 30 seconds, then your price is chosen so high that your profits will be 0.
The experiment proceeds to the first reporting decision in Step 4 if you communicated in Step 2 or if in previous periods you formed a cartel not yet discovered or reported. Otherwise you have to wait for 10 seconds until market prices are revealed in Step 5.

Step 4: First (secret) reporting decision By choosing to push the "REPORT" button, you can report that you have been communicating in the past. As described above, if you are the only one to report, you will not pay the fine; the opposite happens if only your competitor reports; and if both of you report, you will both pay 50% of the fine. If you do not wish to report, push instead the "DO NOT REPORT" button.
When you decide whether or not to report, your competitor will not observe your choice, nor will you observe his or her choice. This information is only revealed when market prices are revealed in Step 5.
If you do not reach a decision within 10 seconds, your default decision will be "DO NOT REPORT".

Step 5: Market prices and second reporting decision In this step your and your competitor's prices and profits are displayed. In case you have formed a cartel not yet discovered or reported, the screen will also display whether or not you or your competitor reported it in the first reporting step (Step 4). If not, you will get a new opportunity to report. If you wish to report, push the "REPORT" button. If you do not wish to report, push instead the "DO NOT REPORT" button. Again, if you are the only one to report, you will not pay the fine. On the contrary, if your competitor reports and you don't, you will have to pay the fine and he will not. If both you and your competitor report, you will both pay 50% of the fine, that is 100 points.

Step 6: Detection probability If this step is reached, you formed a cartel either in the current period or in previous periods. Furthermore the cartel has not yet been discovered or reported. The cartel can nevertheless be discovered. This happens with a probability of 10%. If the cartel is discovered, you and your competitor will have to pay the full fine of 200 points.

Step 7: Summary In this step you learn the choices made in the previous steps: your and your competitor's price choices and profits, your eventual fine, and your earnings. If you paid a fine in this period, you will also know whether your competitor reported the cartel or the government discovered it.
In case a cartel was detected or reported in this period, you will not run any risk of being fined in future periods, unless you and your competitor discuss prices again.
Step 7 will last for 20 seconds.

Period ending and ending of the experimental session After Step 7, a new period starts unless 20 or more periods have passed and the 15% probability of pair dismantling takes place. In that case, the experiment ends.

History table Throughout the experiment, a table will keep track for you of the history with your current competitor. For each previous period played with your current competitor, this table will show your price and profit, your competitor's price and profit as well as your eventual fine.

Payments At the end of the experiment, your earnings in points will be exchanged in Euros. In addition you will be paid the show up fee of €7. Before being paid in private, you will be asked to answer a short questionnaire about the experiment and you will have to handle back the instructions. Please read now carefully the instructions on your own. If you have questions, raise your hand and you will be answered privately.

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS EXPERIMENT AND GOOD LUCK!