Risk Aversion, Prospect Theory, and Strategic Risk in Law Enforcement: Evidence From an Antitrust Experiment *

Maria Bigoni†, Sven-Olof Fridolfsson‡, Chloé Le Coq§ and Giancarlo Spagnolo¶

SSE/EFI Working Paper Series in Economics and Finance No 696

31st March 2008

Abstract

In this paper we investigate the effects of risk preferences and attitudes towards risk on optimal antitrust enforcement policies. First, we observe that risk aversion is negatively correlated with players' proclivity to form a cartel, and that increasing the level of fines while reducing the probability of detection enhance deterrence. This confirms that the design of an optimal law enforcement scheme must keep risk attitudes into account, as suggested by Polinsky and Shavell [22].

We also notice that players' propensity towards communication drops right after detection even if the collusive agreement was successful, and it declines as the sum of the fines paid by a subject increases. This effect could be explained by availability heuristic [17] – a cognitive bias, where people's perception of a risk is based on its vividness and emotional impact rather than on its actual probability.

Our results also confirm the crucial role of strategic risk considerations [3] (analogous to risk dominance for one shot games) in determining the effects of leniency programs. Indeed, we show that the effectiveness of leniency programs in deterring cartels is mostly due to the increased risk of a cartel member being cheated upon when entering a collusive agreement, while the risk of a cartel being detected by an autonomous investigation of the Authority seems to play a less important role.

1 Introduction

This paper reports results from an experiment designed to examine the effects of fines and of leniency programs on firms' decision to form cartels (cartel deterrence). We consider an experiment in which subjects play a repeated Bertrand price game with differentiated goods, running several treatments, which differ in the probability of cartels being caught, in the level of fine and the possibility of self-reporting and getting leniency.

Leniency policies, or programs, grant full or partial reductions of the sanctions to firms that report hard information about their cartel to the Antitrust Authority and cooperate with it along the prosecution phase, helping to convict their former partners. These policies have been introduced in most OECD countries and have become the main tool for cartel discovery and prosecution; their validity and effectiveness, though, is hard to asses since in fact the number of undetected cartels is not observable. Therefore, it is only possible to compare the number of detected cartels with and without leniency programs, but not the total number of existing cartels, meaning that in principle an observed increase in convicted cartels could even be due to

*Many thanks to Magnus Johannesson for discussions and advice related to this project, and to audiences in Rome (World ESA Meeting 2007) and in Gothenburg (Second Nordic Workshop in Behavioral and Experimental Economics, 2007). We also gratefully acknowledge research funding from Konkurrensverket (the Swedish Competition Authority) that made this research possible.

†IMT-Lucca, m.bigoni@imtlucca.it

‡IfN, Sven-Olof.Fridolfsson@ifn.se

§Stockholm Institute of Transition Economics (SITE), Stockholm School of Economics, chloe.lecoq@hhs.se

¶Tor Vergata university, Stockholm Institute of Transition Economics (SITE), Stockholm School of Economics, and CEPR

an increase in cartel activity. For this reason, we think that an experimental approach is needed to collect more evidence about leniency's effects.

The results presented in this paper appear to be also relevant to the analysis of many other forms of multi-agent organized crime – corruption, auditor-manager collusion, corporate crime in general – which share with cartels some crucial features that well designed law enforcement programs may exploit [1]. A first important characteristic of these category of crimes is that cooperation among several agents is required to perform the illegal activity, so that free riding, "hold-up", and "moral hazard" issues become relevant. Moreover, the criminal activity takes the form of an ongoing relation, meaning that the membership of the criminal organization produces flows of present and expected future benefits and damages, instead of isolated gains or losses. Finally, cooperating wrongdoers, by acting together, inevitably end up having information on each others' misbehavior that could be reported to third parties, which is the main characteristic that could be exploited by leniency programs.

In this paper we don't only investigate if, but also how leniency programs work. In particular, we try to figure out which are the determinants of deterrence.
From a theoretical point of view, there are three conditions that have to be satisfied for a cartel to be formed. First, the individual incentive to commit the crime must be strong enough, which means that the expected utility it provides overcomes the expected disutility from the uncertain punishment. Second, the incentive compatibility constraint must be satisfied; so the long run gains from sticking to the collusive agreement must be higher than the short run gains from deviation plus its long run negative consequences. Third, the level of trust among cartel's members must be high enough: indeed we claim that the stability of a cartel does not only depend on each member's incentives to deviate, but also on the perceived risk of being cheated upon by other members, or strategic risk, which increases as trust among cartel's members decrease, and also as the "sucker's" payoff worsen. Strategic risk also affects cartelists' ability to coordinate on the joint profit maximizing equilibrium. Indeed, if the level of perceived risk associated to it is too high, then they could select a different equilibrium, with lower incentives to deviate or better outcomes for the cheated upon players in case a deviation takes place.
According to these considerations, the perceived risk of detection and trust – intended as the perceived risk of being cheated upon – are two important drivers of individuals' proclivity to collusion. In our study, we analyze how different legal frameworks impact on these two types of risk. In doing this, we also keep into consideration the many findings in psychology and in behavioral and experimental economics which show that the way people react to probabilities attached to risky outcomes departs in many ways from the standard model of full rationality.

Our main results are that *(i)* deterrence is generally higher when leniency is granted to the whistleblowers,*(ii)* a negative relation emerges between the sum of the fines paid and participants' willingness to cooperate, and *(iii)* communication rates drop after conviction. Our analysis shows that strategic risk and availability heuristic are among the main drivers of these three outcomes, even if they are generally disregarded in the traditional approach to the study of law enforcement. In particular, strategic risk is determinative both in explaining deterrence under Leniency treatments, and in justifying the drop in communication rates after detection when a deviation took place. Availability heuristic and the salience of fines, on the other hand, are the most plausible reasons why players willingness to communicate decreases after detection even if no deviation has previously taken place, as a fresh memory of the punishment increases the perceived probability of detection. These behavioral biases also seem to motivate the negative effect exerted by the sum of the fines paid on participants' willingness to cooperate.

The paper proceeds as follows: Section 2 presents the literature related with crime deterrence and with the behavioral effects that might affect it. The experimental design and procedure are described in Section 3. Section 4 reports the results and explain the empirical methodology adopted to analyze our data, and Section 5 concludes, also mentioning possible perspectives for further research.

[1] Spagnolo (2004) [26]

2 Related Literature

2.1 Rational agents

Individual benefits and costs from criminal activities. Public enforcement of law is a widely investigated subject since 1968, when Gary Becker [2] published an article which was to become one of the cornerstones of economic analysis of law.
Under Becker's approach, then followed by many scholars such as Polinsky and Shavell [22], individuals are fully rational utility maximizers, and so are offenders. It is assumed that

> a person commits an offense if the expected utility to him exceeds the utility he could get by using his time and other resources at other activities. Some persons become "criminals", therefore, not because their basic motivation differs from that of other persons, but because their benefits and costs differ.

According to this approach, the number of offenses committed by a person can be related, be means of a function, to the probability of conviction, to the punishment imposed in case of detection and to the gains associated with the illegal activity: in practice, the potential offender will commit a crime only if the expected utility attached to the crime's outcome exceeds the expected (dis)utility of the possible sanction.

Organized Crime. As noticed by Spagnolo (2004) [26] and by Motta and Polo (2003) [21], when we consider organized crime as opposed to individual crime, the balance between private benefits and costs from the offense cannot be the only determinant of the decision to commit it. Spagnolo states that "criminal organizations suffer of an intrinsic 'governance problem' since to curb moral hazard and ensure internal cooperation they cannot rely on explicit contracts enforced by the legal system. For this reason, many forms of organized crime must take the form of – or be conducted within – long-term dynamic criminal relationships". Such relationships can be modeled as repeated Prisoner's dilemma like games, in which each player is always tempted to "take the money and run", and does not do that as long as the expected long run gains from sticking to the illegal agreement overcome the short run gains from defection plus the long run consequences that might result from it.
It is precisely on this balance that Leniency programs exert their deterrent effect: in absence of leniency, reporting the crime to the authority is always a dominated action, while with a Leniency Program agents may in fact find it convenient to report when they deviate from the criminal agreement, which can make defection more desirable than adherence to the illegal organization.

Strategic risk According to the prevailing theory, an individual's decision to cooperate – i.e. to take part in a criminal agreement – is determined by the trade off between the consequences he expects from sticking to the agreement and the anticipated outcome from deviation, but not by the consequences possibly yielded by a deviation by some other member of the agreement.
In a recent paper Blonski and Spagnolo [4] critique this approach, suggesting that

> real world agents do care about what would happen if other agents defected from the agreed strategy profile, and that these considerations should not be left out of our models.

They formalize the consequences of a variation in the sucker's payoff in a Prisoner's Dilemma game, and argue that a decrease in the cheated upon player's payoff increase the "strategic risk" associated with playing cooperatively, reducing the sustainability of cooperative equilibria in the long run. To sketch the idea of strategic risk, consider an infinitely repeated PD game, whose stage game is represented in table 1: According to the standard approach, the discouting factor required to sustain collusion must be higher than a threshold value $\underline{\delta}$, identified by the constraint:

$$\frac{r}{1-\delta} \geq t + \delta \frac{p}{1-\delta}$$

	C	**D**
C	r	s
D	t	p

Table 1:

which can be rearranged as

$$\underbrace{\delta\frac{r-p}{1-\delta}}_{\text{LR inc. to coop.}} \geq \underbrace{t-r}_{\text{SR inc. to def.}}.$$

where the left-hand side of the inequality represents the long-run incentive to cooperate, and the right-hand side stands for the short-run incentive to deviate.
Strategic risk approach suggests that also the *short run disincentive to cooperate* $(p - s)$ matters, so the appropriate threshold value for the discount factor is $\delta^* > \underline{\delta}$, determined by:

$$\underbrace{\delta\frac{r-p}{1-\delta}}_{\text{LR inc. to coop.}} \geq \underbrace{t-r+p-s}_{\text{total SR inc. to def.}}$$

Bolnski and Spagnolo's theoretical hypothesis has found some support in the experimental evidence recently provided by Dal Bó and Frechette [6], who study how the evolution of cooperation in infinitely repeated prisoners dilemmas is affected by changes in the difference between the reward from cooperation and the sucker's payoff.

2.2 Behavioral Law and Economics

The models mentioned above proceed with the hypotheses of neoclassical economics, assuming individuals to be perfectly rational expected utility maximizers. Empirical evidence collected by psychologists and by experimental economists, though, casts some doubts about these assumptions: people's behavior has been proved to violate the classical paradigm of *homo oeconomicus* in many ways. More specifically, according to Jolls, Sustein and Thaler (1998) [16], human behavior departs from the standard conception of *homo oeconomicus* under three main respects: they state that people display

- bounded rationality, in that they suffer from certain biases – such as overoptimism, mis-perception of probabilities or self serving biases – and they adopt heuristics that lead to mistakes;
- bounded will power, which sometimes reflects into myopic behavior;
- bounded self interest, meaning that they care for other people's well being.

In light of these findings, they suggest that models of economic analysis of law that do not keep this factors into account may lead to erroneous conclusions, therefore they develop and propose a new approach to this branch of studies, "informed by a more accurate conception of choice, one that reflects a better understanding of human behavior and its wellsprings."
Since their seminal article, Behavioral Law and Economics has developed and has been applied to several specific topics in economic analysis of law (Jolls 2007, [15], and Garoupa 2003 [11] for a critical review).
In what follows, we will focus only on one aspect of bounded rationality: in particular we will consider how a biased perception of risk may affect law enforcement.

Risk attitude Of the various behavioral aspect that might affect law enforcement, risk attitude and risk perception are among the most important ones. Indeed, the effects of risk aversion were already mentioned by Becker (1968) [2], who argues that, if players were risk neutral it would be possible to minimize the costs of apprehension and conviction by lowering the probability of detection arbitrarily close to zero while rising

the severity of the punishment, and states that this should be a fortiori true if offenders were risk avoiders. Notice that this is not only a theoretical matter, but it has strong policy implications which are currently under debate within the Competition Authority of a European country.
Considerations about agents' risk attitude are generally well integrated into the traditional approach to economic analysis of law [2]. But other aspects seem to be important too.

Heuristics and biases. Tversky and Kahneman (1979) [18] already observed that the way people react to probabilities attached to risky outcomes departs in many ways from the basic tenets of expected utility theory: they notice for example that individuals tend to overweight outcomes that are considered certain, relative to outcomes which are merely probable (certainty effect); they also observe that agents round probabilities or outcomes in order to simplify the analysis of risky prospects, and that "a particularly important form of simplification involves the discarding of extremely unlikely outcomes." On the other hand, they also suggest that low probabilities are overweighted, meaning that people overreact to rare events but may underreact to common ones. The interplay of the two last mentioned effects implies that "highly unlikely events are either ignored or overweighted, and the difference between high probability and certainty is either neglected or exaggerated." This consideration clearly plays a role for the analysis of optimal law enforcement: indeed, if a very small probability of liability is approximated to zero, then Becker's argument claiming that it is possible to reduce prosecution costs without affecting deterrence, by lowering the probability of detection and harshening the penalties, does not hold anymore.

The weight attached by individuals to the risk of conviction may be also affected by another behavioral bias: the salience effect. As highlighted by Akerlof (1998) [1], outstanding events and vivid information may exert undue influence on decisions: he refers to this principle to explain time inconsistent decisions – arguing that present costs and benefits are salient if compared to future ones – and to provide a possible reason for the "undue" obedience to authority – which can emerge when disobedience is perceived as more salient than compliance because it implies a deviation from the status quo or from a previous course of actions, and when some degree of disutility is attached disobedience.
Similarly, one could argue that an exacerbation of punishments may increase deterrence since extremely harsh penalties are more salient, than overweighted.
A close but different behavioral effect concerning probability perception, foregrounded by Tversky and Kahneman (1982) [17], is "availability heuristic": a mechanism by which occurrences of events associated with extremely high utilities or disutilities are perceived as being more frequent than they actually are. The main difference between availability heuristic and salience is that according to the first one risk perception is driven by memory-dependent mechanisms, while the second one states that attention is guided by the most vivid present stimuli.
Availability heuristic has been tested and confirmed by Folkes (1988)'s studies on the risk perceived by consumers when purchasing a product [10], and by a recent study by Keller et al. (2006) [19] on perception of flood risk, which testifies that past experience of flooding increases risk perception independent on the information exogenously provided about this risk. This piece of evidence supports the hypothesis that people who experienced past flooding events and have of them images that are tagged with affect perceive the same probability information differently from people without such memories.
Availability heuristic and salience can be interpreted as a result of the interplay of two fundamental ways in which human beings comprehend risk: "risk as analysis and risk as feelings" (Slovic et al., 2004 [25]), the first one being based on the brain "analytical system" – which encodes reality in abstract and symbolic terms, builds logical connections between events and requires logical or empirical justification for actions – the second one being related to the "experiential system" – which on the contrary is associated with the experience of affects, motivate actions on the basis of the emotional memory of related events and encodes reality in concrete images, metaphors and narratives. The authors suggest that availability heuristic may work because images and events that are tagged with affect are more easily recalled or imagined. Events that are more sensational or salient are also more affectively charged, which might explain the overestimation of their frequency or probability, both ex ante, before they are actually experienced by the subjects, and ex

[2] see, for example, Polinsky and Shavell (2000) [22]

post, when individuals have memories associated with these events.

Empirical evidence As we have just seen, there are many psychological effects that might affect law enforcement through the way people perceive the risk of being liable. Nonetheless, to our knowledge, the empirical and experimental evidence collected to test the different theoretical predictions in the specific context of crime deterrence is not very rich.

Levitt performed some interesting field studies about the actual relation between punishment and deterrence, also keeping into account possible bias like criminals' myopia or overoptimism (Levitt, 1998 [20]), but experimental approach seems to be more suitable to analyze psychological motives behind peoples responses to legal sanctions. In this second field of research, we should mention a study performed by Cason and Gangadharan (2006) [5], who experimentally analyze a model of compliance developed by Harrington (1988) [12] in which the enforcement agency modifies the inspection frequency and severities of the penalties depending on the firms past compliance. They find that violation rate do not change as sharply as predicted by the model when the probability of detection and size of the fine change, and show that the observed behavior might be captured by a quantal choice model, which accounts for boundedly rational decision making by allowing individuals to make errors, assuming though that errors that are more costly are also less probable.

A second experimental work testing predictions of behavioral economics in the context of law enforcement has been carried on by Jaquemet et al. (in press) [14], who study the role of optimism bias on the monitoring of illegal activities. They show that subjects exhibit a strong tendency to under-evaluate their own likelihood of experiencing an unfavorable event as compared to the one of others, which leads to a lower level of deterrence.

A third empirical work on punishment and deterrence has been recently presented by Fishman and Pope (2006) [9]: they study punishment induced deterrence, i.e. "the subsequent deterrent effect [...] that actually experiencing punishment for a crime has on the specific individual who was punished, conditioning for changes in expected benefits and costs of future criminal activity". Using field data from the movie-rental market, they explore the effect of having to pay a late fee on costumers' movie-rental and movie-return decisions, and show that:(*i*) experiencing punishment decreases the offender's crime rate (in the short run); (*ii*) salience (size and temporal proximity) of punishment is positively related with deterrence and (*iii*) the effect does not vanish with experience.

Their results confirm that the experience of a penalty affects the weight individuals attach to punishment when they have to decide whether to comply or not to a prescription, an effect that to us could be attribute to the aforementioned availability heuristic.

Organized Crime and Trust. Assessing and evaluating the risk of liability is an important problem for every potential offender, regardless the nature of his crime. When we focus on organized crime, though, another significant element has to be taken into account, namely trust between members of the "criminal organization". Reciprocal trust is important for two reasons: first, as mentioned before, organized crime can be modeled as a repeated prisoner's dilemma like situation, in which each player will choose to stick to the criminal agreement only if he has a strong enough belief that the other will do the same. Second, cooperating wrongdoers, by acting together, inevitably end up having information on each others' misbehavior that could be reported to third parties, and each of the members of the organization has to be sufficiently confident that this will not happen.

Behavioral and experimental economics offer a rich literature about trust; for sake of conciseness, we cannot mention it all, and we will only cite one recent paper by Sapienza, Toldra and Zingales (2007) [23], whose results are particularly interesting to us. They study a standard trust game and, among other things, they find that a trusting behavior is determined by three main factors: beliefs about others trustworthiness, risk aversion and other regarding preferences. Considerations about the third element are outside the scope of our work, while the first two factors play a crucial role for the analysis of organized crime. The relation between risk aversion and trust reveals that offenders' risk attitudes affect deterrence not only via the risk of liability, but also because of the risk of betrayal on behalf of some other member of the criminal organization; beliefs about others' trustworthiness, on the other hand, appears to be even more important in repeated prisoner's dilemma like games that they are in one shot trust games, since they affect the level of perceived strategic risk, modifying the critical discount factor required to sustain the illegal agreement.

3 Experimental Design

In our experiment, each subject represented a firm and played in anonymous two-persons group a repeated duopoly game. In every stage game, the subjects had to take three types of decisions. First, the subjects had to choose whether or not they wanted to form a cartel by discussing prices. Second, they had to choose a price in a discrete Bertrand price game with differentiated goods. Third, the subjects could choose to self report cartels to a competition authority. The attractiveness of this latter opportunity depended on the details of the antitrust law enforcement institution - the treatment variables of our experiment.

3.1 The Bertrand game

In each period, the subjects had to choose a price from the choice set $\{0, 1, ..., 11, 12\}$. Their payoff depended on their own price choice and on the price chosen by their competitor and were reported in a payoff table distributed to the subjects. This table indicated a subjects' profits depending on its own price choice and the price chosen by its competitor (see figure 1) and was derived from the following standard linear Bertrand game. (The details of the Bertrand game were not described to the subjects.)

The demand function for each firm i was given by:

$$q_i(p_i, p_j) = \frac{a}{1+\gamma} - \frac{1}{1-\gamma^2}p_i + \frac{\gamma}{1-\gamma^2}p_j$$

where p_i (p_j) is the price chosen by firm i (competitor j), a is a parameter accounting for the market size and $\gamma \in [0, 1)$ denotes the degree of substitutability between the two firms' products. Each firm faced a constant marginal cost, c, and had no fixed costs. The profit function, $\pi_i(p_i, p_j)$, was thus given by

$$\pi_i(p_i, p_j) = (p_i - c)q_i.$$

In our experimental setup, we chose $a = 36$, $c = 0$ and $\gamma = 4/5$ and restricted the subjects' choice set to $\{0, 2, ..., 22, 24\}$. These parameters yield the payoff table distributed to each subject. To simplify the table we also relabeled each price by dividing it by 2 and rounded the payoffs to the closest integer. In the unique Bertrand equilibrium, both firms charge a price equal to 3 yielding per firm profits of 100. The monopoly price (charged by both firms) is 9, yielding profits of 180. Note also that a firm would earn 296 by unilaterally and optimally undercutting the monopoly price, i.e. by charging a price of 7. In this case the other (cheated upon) firm only earns a profit of 20. Similarly, there are gains from deviating unilaterally from other common prices than the monopoly price as well as associated losses for the cheated upon firm; in the range of prices in between the Bertrand price and the monopoly price, ie in the range $\{4, ..., 8\}$, these gains and losses are smaller than when a subject deviates unilaterally from the monopoly price.

3.2 Cartel formation

Throughout the experiment, the subjects could form cartels by discussing prices. At the beginning of every period, a communication window opened if and only if both subjects agreed to communicate. This communication stage, which is described in more detail below, was designed in such a way that it would result in a common price on which to cooperate. This agreed upon price was non-binding, however, and therefore each subject could cheat on the agreement by subsequently charging a price different from the agreed upon price.

Whenever two subjects chose to communicate, they were considered to have formed a cartel. In this case, the subjects risked to be fined as long as their cartel was not detected by the competition authority. This implied that two subjects could be fined in a period even if no communication took place in that specific

		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

Figure 1: Payoff table

period; for example, two subjects could be fined in a period in which they did not communicate if they communicated in the previous period and the competition authority did not detect the associated cartel in that period. Once a cartel was detected, however, it was considered to be dismantled and in subsequent periods, the former cartellists did not run any risk of being fined unless they communicated again.

3.3 Treatment variables

Whenever two subjects had formed a cartel, a competition authority could detect the cartel and convict its members for price fixing. Detection could happen in two ways. First, in every period, the competition authority detected cartels with an exogenous probability, α. If this happened, both cartel members had to pay an exogenous fine, F. Second, the cartel members could self-report the cartel, in which case the cartel members were convicted for price fixing with certainty. If this happened, the size of the fine depended on the details of the law enforcement institution.

We ran eight treatments of our game, adopting a *between subjects* design, so that every subject only played the game under a single treatment. The six treatments differ in the specific type of antitrust law adopted (with or without leniency for those who report the cartel), in the probability of detection and in the size of the fine imposed to the detected cartels' members. The differences between the treatments are summarized in table 2.

Treatment	**fine (F)**	**probability of detection (α)**	**report**	**report's effects**
ANTITRUST	200	0.10	Yes	pay the full fine
	1000	0.02		
	300	0.2		
	1000	0		
LENIENCY	200	0.10	Yes	no fine (half the fine if both report)
	1000	0.02		
	300	0.2		
	1000	0		
COMMUNICATION	0	0	No	–

Table 2: **Treatments**

Antitrust Policy. Our baseline treatment corresponds to a laisser faire regime and is denoted COMMUNICATION: in this treatment, $\alpha = F = 0$ so that forming a cartel by discussing prices is legal. To simplify the instructions and to eliminate irrelevant alternatives, subjects were not allowed to report cartels. In the five other treatments cartel members were allowed to report cartels in which they participated. The ANTITRUST treatments corresponds to traditional antitrust laws without any leniency program: in case a report took place, both cartel members (including the reporting one) had to pay the full fine F. The LENIENCY treatments corresponds to current antitrust laws embedded with a leniency program: in case the cartel was reported by one of the cartel members only, the reporting member paid no fine while the other one paid the full fine, F; if instead both cartel members reported the cartel simultaneously, both paid a reduced fine equal to $F/2$. Note that under Leniency treatments a player who decides to deviate from the agreement is always better off if he simultaneously reports the cartel. So, in principle, the introduction of Leniency Programs should tighten the incentive compatibility constraint, since deviating becomes less risky, thus more attractive. Leniency should also harshen strategic risk, because the cheated upon firm not only suffer for the exploitation, but also has to pay the fine for sure.

Probability of Detection and Size of the Fine We also vary the probability of detection and the size of the fine across treatments: in particular, per each of the two considered antitrust policies, we have two treatments with an expected fine of 20 – one with a high probability of detection ($\alpha = 0.10$) and a low fine

($F = 200$), the other in which, vice versa, the probability of detection is low ($\alpha = 0.02$) and the fine is high ($F = 1000$) – and one treatment in which the expected fine is higher: $\alpha = 0.2$ and $F = 300$.
A different mix of magnitude and probability of the fine affects the riskiness of the collusive outcomes, but, as discussed above, it is not obvious what kind of effect this could generate in terms of deterrence. For example, if agents are perfectly rational and risk neutral, and they do not react to strategic risk, their preferences should be only marginally affected by a change in the determinants of the fine which leaves the expected fine constant. Such a change, in fact, has no impact on the expected collusive profits and has at most a marginal effect on the profitability of a deviation from collusion. As suggested by Becker, if on the contrary agents are risk averse we should observe higher deterrence when the size of the fine is higher and the probability lower, whether leniency programs are present or not. In addition, under Leniency Programs an increase of the magnitude of the fine dramatically reduces the profit a firms obtains when "cheated upon", that is when their opponent deviates from the collusive agreement. As mentioned above, these profits play no role in the standard theory, since they do not affect the conditions for an agreement being supportable in equilibrium, but they do matter for strategic risk, because they enter the definition of the short run disincentive to cooperate. Moreover, all the behavioral biases affecting risk perception we enumerated above might play a role in determining the outcome of such changes in the components of the expected fine.
The experiment we present here was not specifically designed to test any of these theoretical predictions, but to investigate the effects of different legal settings in light of them. With the same exploratory aim, we designed two additional treatments –one with Leniency, one without it – in which the fine is high ($F = 1000$), but can be inflicted only in case of reporting because the probability of detection is set to be null ($\alpha = 0$): that is, the antitrust authority is not able to discover any cartel that is not reported by at least one of its members. Comparing the results of these treatments with those we get from the corresponding treatments where the size of the fine is the same ($F = 1000$) but the probability of detection is positive ($\alpha = 0.02$), we can study if a very small probability of detection is overweighted or underestimated, and we can also check for the role played by strategic risk in this setting. Indeed, if strategic risk did not affect players' decision, we should not observe any deterrence in the treatment with $\alpha = 0$.

3.4 Experiment's timing and rematching procedure

At the end of each period, subjects were rematched with the same competitor with a probability of 85%. With the remaining probability of 15%, all subjects were randomly matched into new pairs. When this happened, cartels formed within the previous match could not be fined anymore. The experiment lasted at least 20 rounds. From the 21st round on, we introduced a termination probability of 15%, while the probability of rematching was reduced to 0. Subjects were also informed that the game would have been stopped in case the experiment lasted for more than 2 hours and 30 minutes. This latter eventuality never took place.

This re-matching procedure had several advantages. First, the subjects were playing truly *infinitely repeated games* without problems associated with end effects. Second, each subject played several repeated games against different competitors, which allowed us to observe the subjects' behavior in a larger number of repeated games.

Before the experiment started, the subjects were paired with the same competitor for five practice periods. Participants were informed that during these practice periods, they were paired with different competitors than those that they faced in the first period of the 'true' (i.e. remunerated) experiment. They were also told that profits realized during the trial periods were not to affect their earnings from the experiment.

3.5 The timing of the stage game

In the Antitrust and Leniency treatments, a stage game consisted of 7 steps (see figure 2). In the Communication treatment steps 4,5 and 6 were skipped.

We will now describe more in details each single step.
Step 1: Communication decision. Each subject was asked whether or not he wished to communicate

Figure 2: Stage game

with his competitor. If both subjects pushed on the yes button within 15 seconds, the game proceeded to step 2. Otherwise the two subjects had to wait for an additional 30 seconds before pricing decisions were taken in Step 3. In all periods, subjects were also informed whether they were matched with the same opponent as in the previous round or if a re-match had taken place.

Step 2: Communication. If both subjects decided to communicate in step 1, a window appeared on their computer screen asking them to simultaneously state a minimum acceptable price in the range $\{0, ..., 12\}$. When both of them had chosen a price, they entered a second round of price negotiations, in which they could choose a price from the new range $\{p_{min}, ..., 12\}$, where p_{min} was defined as the minimum among the two prices selected in the previous negotiation round. This procedure went on until 30 seconds had passed. The resulting minimum price p_{min} was referred to as the agreed upon price.

Step 3: Pricing. Each subject had to choose his price from the choice set $\{0, ..., 12\}$. Possible price agreements reached in step 2 were not binding. The subjects were informed that if they failed to choose a price within 30 seconds, then their default price would be so high that their profits became 0.

Step 4: First Reporting Decision. If communication took place in the current period or in one of the previous periods and had not yet been discovered by the competition authority, subjects had a first opportunity to report the cartel.

Step 5: Market prices and second reporting decision. Subjects were informed about the prices set by their opponent, their own profits and the profits of their competitor, gross of the possible fine. If communication had taken place in the current period or in one of the previous periods and had not not yet discovered by the competition authority and nobody had reported it in step 4, subjects had again the opportunity to report the cartel. The crucial difference between this second reporting opportunity and the first one is that the subjects knew the price chosen by their competitors.

Step 6: Detection. If communication took place in the current period or in one of the previous periods and had not yet been discovered or reported in steps 4 or 5, the competition authority discovered the cartel with probability α.

Step 7: Summary of the current period. At the end of each period, all the relevant information about the stage game are displayed: agreed upon price (if any), prices chosen by the two players, possible fines and net profits. In case players were fined, they were also told how many players reported.

Note that with our experimental setup subjects have two opportunities to report the cartel: first at step 4, right after having set their price, then again at step 5, after having been informed about the price chosen by their opponent. In our design, reporting can thus be used for two different purposes: (i) deviating subjects may report to get protection against prosecution and (ii) cheated upon subjects may report to punish their opponents, if they have not reported before.

3.6 Measuring risk aversion

We needed also a measure of risk aversion, to check for the effects it has on subjects' decision to communicate; due to the length of our main game, though, we could not adopt the – now standard – ten paired lotteries choice proposed by Holt and Laury (2002) [13], which is too time consuming, and we chose a shorter procedure, which provided us with a less precise but still reliable proxy.

At the end of the main game, each of the subjects was presented the following situation: given an initial endowment of 25 Euro they were asked to choose how much to keep and how much to invest into a risky

project, yielding a return equal to 2.5 with 50% probability, and a return equal to 0 otherwise. After all the answers had been collected, a coin was tossed to determine the outcome of the risky project and only one of the subjects was randomly drawn to be paid according to his choice. It was made clear to the subjects that their choice and earnings in this second game could not affect in any way the profit they had made in the previous game.
Note that the initial endowment was chosen so that the amount of money at stake had approximately the same magnitude than the average cumulated profit in the main game: the amount of money invested should then be a reliable proxy of the degree of risk aversion displayed by the subjects when playing the Bertrand game.

3.7 Experimental procedure

Our experiment took place in May 2007 at Tor Vergata University (Rome, Italy) [3]. Session lasted on average 2 hours, including instructions and payment. We ran all the eight treatments and the investment game to check for risk attitude, involving 282 students in total. The average payment in the main game was equal to 23.60 €, with a maximum of 34€and a minimum of 11€, while the average payout for the investment game was 30.33€, with a minimum of 0 and a maximum of 62.5€.
For some of the results, we will present also data collected within the same experimental project, in March and April 2007 at the Stockholm School of Economics (Sweden). In Stockholm we did not run the investment game, while the Bertrand game was exactly alike the one we did in Rome. We ran only 5 treatments in Stockholm, namely: Communication plus the two Leniency and two Antitrust treatments in which the expected fine is equal to 20. 78 students were involved, in all. The average payment in Stockholm SEK 248[4], with a minimum of 130 SEK and a maximum of 330 SEK.

The experiment was computerized, and the programs were written with z-tree [8]. At the beginning of each session, subjects were welcomed in the lab and seated, each in front of a computer. When all subjects were ready, a printed version of the instructions and the profit table was distributed to them. Instructions were read aloud to ensure common knowledge of the rules of the game. The subjects were then asked to read the instructions on their own and ask questions, which were answered privately. When everybody had read the instructions and there were no more questions (which always happened after about fifteen minutes), each subject was randomly matched with another subject for the five practice rounds. After the practice rounds, participants had a last opportunity to ask questions about the rules of the game. Again, they were answered privately. Then they were randomly rematched into new pairs and the real game started.

At the end of each session, the subjects were paid privately in cash. The subjects started with an initial endowment of 1000 points in order to reduce the likelihood of bankruptcy. At the end of the experiment the subjects were paid an amount equal to their cumulated earnings (including the initial endowment) plus a show up fee of 50 SEK in Stockholm and 7 Euros in Rome. The conversion rates were 20 points for 1 SEK in Stockholm and 200 points for 1 Euro in Rome.

4 Results

In this section, we will first present some aggregate results: we will briefly analyze the data collected through the investment game, and we will compare the average rate of communication in the different treatments.
We will then study what are the drivers of the subjects' decision to communicate, according to the results we got from a logit regression.
In the last part we will focus on the effects of conviction on players' behavior, analyzing how their willingness to communicate changes after they had got fined.

[3] Treatment Antitrust with $\alpha = 0$ and $F = 1000$ was run in an additional session, taking place at Tor Vergata University in December 2007. Students having taken part to previous sessions were not admitted.
[4] At the time of the experiment, 1 SEK=0.109 Euro

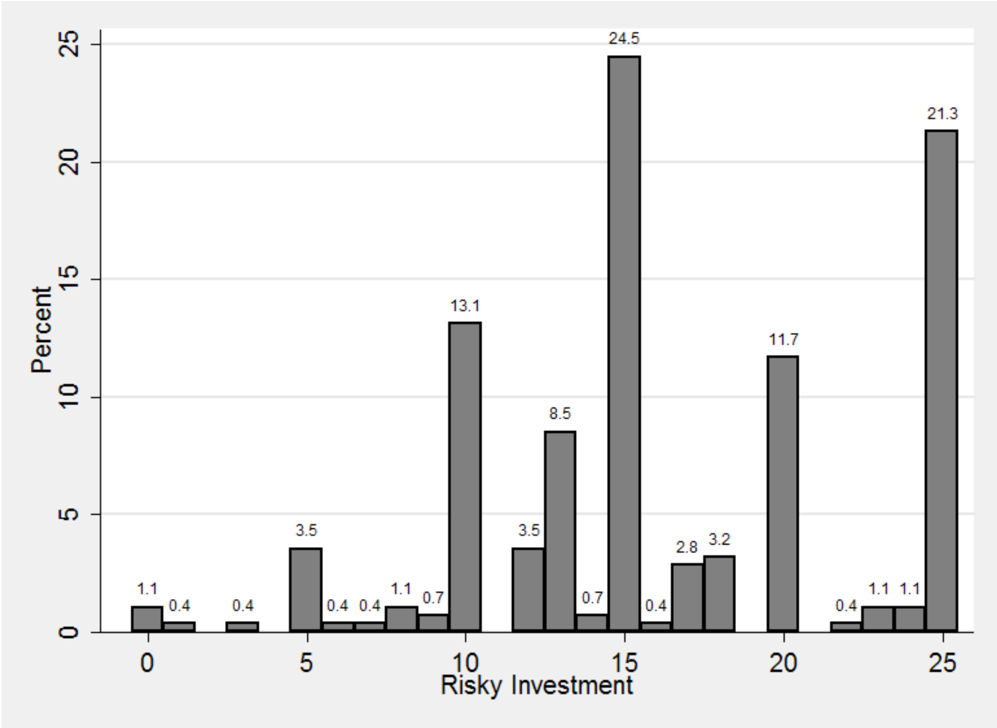

Figure 3: Distribution of investment choices

4.1 A proxy for risk aversion

Figure 3 displays the distribution of choices in the investment game: we find that more than 20% of the players are risk neutral or risk lover, which is in line with Holt and Laury (2002)'s findigs; consistently with most empirical and experimental findigns (see Eckel and Grossman, in press [7]) we also observe that women invested significantly less than men: the correlation between gender and investment is 21.65%, (significant at the 0.1%).

4.2 The decision to communicate under different treatments

Table 3: Communication decision rates under different treatments

α	F	**Antitrust**	**Leniency**
0.1	200	0.59	0.34
0.02	1000	0.38	0.25
0.2	300	0.45	0.43
0	1000	0.54	0.28
Communication		0.78	

Data collected in Rome. 5026 observations in total.

Here we present an overview of our results about how the legal framework affects the individual decision of taking part in a cartel, when this choice is illegal and risky. Notice that in our setting, communication is risky only when subjects are not currently cartel members, because the decision to communicate again when a cartel has already been established does not affect the probability of detection, nor the punishment imposed in case of liability. For this reason, for Antitrust and Leniency treatments, we restrict our attention to the attempts of communicate made by subjects that are not already members of a cartel. Comparing the rate of communication decision observed under the six Antitrust and Leniency treatments with those obtained in the benchmark treatment, Communication, we can evaluate the success of different legal frameworks in terms of ex ante deterrence, that is the main objective of Antitrust policies. A first look at these data leads to some preliminary observations:

- A large increment in the *actual* fine increases deterrence
- A large increment in the *expected* fine does not increase deterrence
- Given α and F, deterrence is higher under leniency
- When $\alpha = 0$ deterrence does not drop under leniency, but it does under antitrust.

To assess the significance of these results and to individuate the drivers of the communication decision, we need to study our data more in detail, taking into account some technical aspects of our dataset that make the econometric analysis less straightforward, as we shall explain in next paragraph.

4.3 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 the observed differences across treatments. Given the rematching procedure we adopted, we need to account for correlation between two observations from the same individual, as well as correlation between two observations from different individuals who belong to the same duopoly. Moreover, since the experiment was run in two different cities, when we pool together the data gathered in Rome and Stockholm we also have to control for the possible correlation among observations collected in the same city. To this purpose, we adopted multilevel random effect models.

Since in our experiment a subject may take part in more than one duopoly during the game, the random effects at the subject level and at the duopoly level are not nested, which makes it difficult to estimate a model with a random effect at the duopoly level and a random effect at the subject level at the same time. To overcome this complicacy, we hypothesized the presence of a random effect for every subject within any particular match (which accounts for the correlation among observations pertaining to the same match), nested with a random effect for every subject across different matches, which is in turn nested with a random effect at the city level.

To analyze data collected both in Rome and in Stockholm, we adopt a four-levels random intercept logit model of the following form:

$$CommDec_{hijk} = \mathbf{x}_{hijk}\boldsymbol{\beta} + \eta^{(2)}_{ijk} + \eta^{(3)}_{jk} + \eta^{(4)}_{k}$$

where h, i , j and k are indices for measurement occasions, subjects in matches, subjects across matches and cities, respectively. $CommDec_{hijk}$ represents the $h-$th communication decision of subject j in match i, and in city k. $\mathbf{x}_{hijk}$ is a vector of explanatory variables (including the constant), with fixed regression coefficients $\boldsymbol{\beta}$; $\eta^{(2)}_{ijk}$ represents the random intercept for subject j in match i, and in city k (second level), $\eta^{(3)}_{jk}$ represents the random intercept for subject j in city k (third level) and $\eta^{(4)}_{k}$ represents the random intercept for city k (fourth level). Random intercepts are assumed to be independently normally distributed, with a variance that is estimated through our regression.

When comparing observations collected in a single city, we adopt a model which is analogous to the previously described one, but without the last level.

To estimate our model used GLLAMM [5], a software specifically designed to provide a maximum likelihood framework for models with unobserved components, such as multilevel models, certain latent variable models, panel data models, or models with common factors.

[5] see Rabe-Hesketh and Skrondal, 2004 [24] and http://www.gllamm.org

4.4 Drivers of the decision to communicate

In this section we present the results of a logit regression we ran to assess which are the most important factors affecting subjects' decision to communicate. For these results, we only consider the data we collected in Rome, therefore we will adopt a three levels random intercept logit model of the form presented above. Table 4 presents the results of this regression[6].

Table 4: Results of the logit regression.

	Coefficient	Std. Err.
$A_{0.1,200}$	-0.425	0.488
$A_{0.02,1000}$	-1.890***	0.566
$A_{0.2,300}$	-1.704***	0.500
$A_{0,1000}$	-0.377	0.506
$L_{0.1,200}$	-2.340***	0.387
$L_{0.02,1000}$	-3.198***	0.529
$L_{0.2,300}$	-1.764***	0.475
$L_{0,1000}$	-2.631***	0.491
Paid fine (/1000)	-1.048***	0.216
Frequency of detection	-0.073	0.598
Cumulated earning (/1000) -0.002	0.083	
Investment (/25)	1.216**	0.557
Constant	0.927*	0.517
LogLikelihood	-2666.716	
#obs.	5398	

Data collected in Rome. 5026 observations in total.

The dependent variable is the decision to communicate: as mentioned before, since we are interested in deterrence of cartel formation, we do not consider in this regression the decisions taken by subjects already members of an existing cartel.
The independent variables are:

- 8 dummy variables, one for each treatment (communication is the benchmark)
- the total fine paid by the subject up to the period in which he takes the decision.
- the frequency of detection observed by the subject, measured as the ratio between the number of times a cartel he belonged to was detected by the Authority (without it being reported) and the number of periods in which the subject had taken part in a cartel.
- the subject's cumulated earnings.
- the amount of money put into the risky asset in the "investment game"

Note that the cumulated fine and cumulated earnings have a much higher magnitude than the other regressors; for this reason, we divided those numbers by 1000, so that all the variables had approximately the same scale. For similar reasons, the sum chosen by the subject in the investment game enters the equation in terms of ratios of the total amount of money available, namely 25.

The regression's results substantially confirm our preliminary observations.

[6]Note: In this table as well as in the following results, the symbols ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Result 1: the size of the *actual* fine matters. Deterrence is significantly higher when **actual fine** is higher, the expected fine being the same. According to one-sided z-tests, we have:

$$A_{0.02,1000} <^{**} A_{0.1,200} \text{ and } L_{0.02,1000} <^{*} L_{0.1,200}$$

Result 2: the size of the *expected* fine has no direct effect on deterrence. A higher expected fine does not necessarily imply higher deterrence:

$$A_{0.1,200} >^{**} A_{0.2,300} \text{ and } L_{0.1,200} \approx L_{0.2,300}$$

but

$$A_{0.02,1000} \approx A_{0.2,300} \text{ and } L_{0.02,1000} <^{***} L_{0.2,300}$$

These first two results seem to confirm Becker's suggestion that it is possible to achieve higher deterrence while decreasing prosecution costs by increasing the size of the fine and reducing the effort spent in investigation.

Result 3: deterrence is generally higher under Leniency. Only for the two treatments with higher expected fine ($\alpha = 0.2$ and $F = 300$) the effect does not seem to be significant:

$$L_{0.1,200} <^{***} A_{0.1,200}$$
$$L_{0.02,1000} <^{**} A_{0.02,1000}$$
$$L_{0.2,300} \approx A_{0.2,300} L_{0,1000} <^{***} A_{0,1000}$$

Result 4: deterrence when $\alpha = 0$. As mentioned before, according to the standard theory we should not observe any deterrence when the probability of detection is null. Indeed, we notice that the coefficient for $A_{0,1000}$ is not significantly different from zero. Remarkably, a different result holds for Leniency treatments: a small probability of detection seems to play no role in deterrence under Leniency, when the fine is high enough:

$$L_{0.02,1000} \approx L_{0,1000}$$

Currently, some concern has been expressed about the contingency that the many leniency applications keep the agency busy with prosecution, to the detriment of investigation; thus, the probability that a cartel is detected because of the autonomous investigation by the authority would decrease (lower α.)
According to our results, this should not be a serious problem: we observe that deterrence remains high even if $\alpha = 0$, provided that the fine is high enough.

Now we would like to examine these results in light of the theories about players' behavior mentioned in section 2, to see if and to which extent these theories are supported by the evidence we collected.

Risk aversion. Our regression shows that subjects who chose to put more money in the risky lottery of the investment game are also more incline to communicate, which is in line with the ideas discussed in section 2.2. There, we have seen that risk aversion can affect deterrence in at least two ways: first, it increases the perceived dis-utility connected to the risk of conviction; second, it can also worsen the perceived risk of being betrayed by the other player, in case a cartel is established. A certain degree of risk aversion in some of the players is also a possible reason why deterrence is higher in treatments $A_{0.02,1000}$ and $L_{0.02,1000}$ than in treatments $A_{0.1,200}$ and $L_{0.1,200}$, respectively, even if the expected fine remains constant.

Strategic risk. We do not observe any significant difference between the levels of deterrence under Leniency when the fine is high ($F = 1000$) and the probability of detection is low or null. This fact supports the idea that in presence of leniency programs it must be the risk of being cheated upon by the other cartelist – i.e. strategic risk – and not the risk of being liable that determines deterrence. In treatments Antitrust, on the other hand, we observe that deterrence when the probability of detection is low but positive is significantly higher than when this probability is null. Moreover, the estimated coefficient for treatment dummy $A_{0,1000}$ is not significantly different from zero. This is not in contrast with the theory of strategic risk. In fact, both findings suggest that it is the risk of detection and punishment – and not the risk of being betrayed by other cartelists – that discourage players from colluding, when no leniency is granted to those who report the cartel. In fact, in this case reporting the cartel when deviating from the collusive agreement is not a dominant strategy, so it is possible that the perceived strategic risk is lower and may even be negligible when there is no risk of detection.

Perception of small probabilities. We mentioned above that according to the research developed by Tversky and Kahneman [18], the perception of very small probabilities may have ambiguous outcomes: it is possible that they are overemphasized or even approximated to zero, depending on the context and on the individual characteristics of the subject. The significant difference between the estimated coefficients for $A_{0,1000}$ and $A_{0.02,1000}$ seems to imply that in general, in our game a very small probability of detection is not disregarded. In a sense, this is another element supporting the importance of strategic risk in the situation we depicted. In fact, the difference in deterrence disappears under the two Leniency treatments with fine equal to 1000. If players do not approximate a probability of 2% to zero, then this proability must be disregarded because other factors predominate, and among them strategic risk appears to be one of the most plausible.

Availability heuristic. The hypothesis that people's perception of a risk is based not only on its actual probability, but also on its vividness and emotional impact is validated by our data. According to our regression, the sum of the fines paid by a subject in previous periods has a significant and substantial negative effect on his willingness to communicate, meaning that subjects who have paid a very high fine, but also those who have repeatedly paid a lower fine, are less incline to collude again. This is in line with the findings of Fishman and Pope (2006) [9] about punishment-induced deterrence and with the idea that the experience of the penalty affects subjects' willingness to commit the crime, the more the harsher is the penalty, or more generally the stronger is its memory.
The sum of the fines paid appears to be the only factor affecting players behavior throughout the game, thus introducing some dynamics in their choice pattern. Communication decision does not seem to be affected by the player's cumulated earnings, which is obviously highly correlated with the number of periods elapsed since the beginning of the game and of the match. This seems to rule out an endowment effect, and any learning effects other than the one deriving from the experience of punishment.

4.5 Post-conviction Behavior

In this section we will describe how players modify their decision to communicate in the periods following conviction. First, we introduce a distinction between two categories of conviction, according to the outcome they generate for the players in terms of payoffs: we will say that conviction has a

- *symmetric outcome*, if it hurts both players (approximately) in the same way. For example, this is the case when a cartel is detected by the Authority, but also when reporting is used as a punishment device under Leniency. In this last case, only one of the players deviated from the collusive agreement, thus getting higher profits, but the the cartel was reported only by the other player: both players then obtain low profits, because one of them was cheated upon, the other one got fined.
- *asymmetric outcome*, if one of the cartel's members got hurt more than the other, as when only one player deviate and simultaneously reports the cartel.

In this section we use data collected both in Rome and in Stockholm, since we are not going to use the information about subjects risk aversion. We will also pool together the data across treatments.
First, we observe that conviction has a symmetric outcome 94.12% of the time under Antitrust treatments, and only 37.90% of the times under Leniency. This is mainly due to the fact that deviators often report

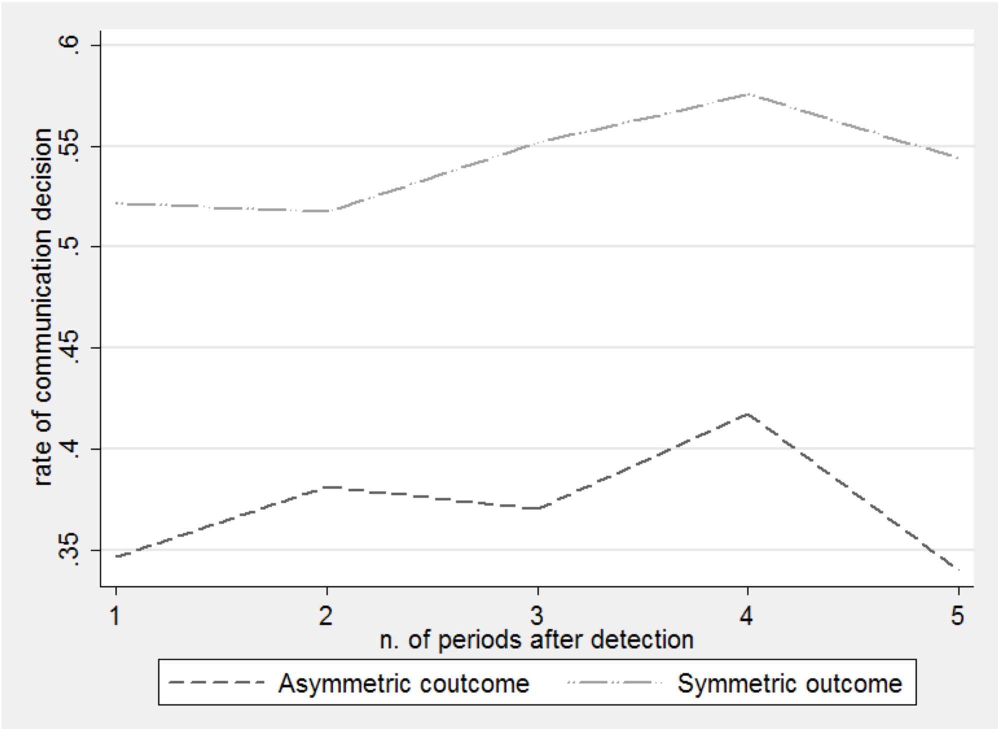

Figure 4: Post-conviction rate of communication decision.

the cartel to protect themselves from fines under Leniency, but not under Antitrust: indeed, under Leniency treatments, players who undercut the agreed upon price also reported the cartel in 62.38% of the cases, while under Antitrust treatments this percentage drops to 4.95%. So, if conviction with asymmetric outcomes discourages communication more, then we would have at least a partial explanation of why we generally observe more deterrence under Leniency treatments.

Figure **??** displays the percentage of convicted agents (vertical axis) who chose to communicate again in the five periods following conviction (horizontal axis), separately for symmetric and asymmetric conviction outcomes. We observe that, as a consequence of asymmetric conviction, most of the subjects decide not to communicate anymore with the same competitor, while the about one subject out of two chose to communicate again when conviction'outcome was symmetric.
To check whether this finding is significant and robust to other factors, we ran the following four levels random intercept logit regression:

$$CommDec_{hijk} = \beta_0 + \beta_1 CumEarnings_{hijk} + \beta_2 Fine_{hijk} + \beta_3 Symm_{hijk} + \\ + \beta_4 SymmXFine_{hijk} + \eta^{(2)}_{ijk} + \eta^{(3)}_{jk} + \eta^{(4)}_{k}$$

where, the dependent variable is communication decision in the period immediately following conviction, $CumEarnings$ represents the cumulated earnings of the subject, $Symm$ is a dummy variable equal to 1 when the outcome of conviction was symmetric, $Fine$ measures the fine actually paid by the convicted subject, and $SymmXFine$ represents the interaction between these two factors. Finally, as explained before, $\eta^{(2)}_{ijk}$ represents the random intercept for subject j in match i, and in city k (second level), $\eta^{(3)}_{jk}$ represents the random intercept for subject j in city k (third level) and $\eta^{(4)}_{k}$ represents the random intercept for city k (fourth level).

The results of this regression, displayed in table 5 show that symmetry of conviction outcomes positively and significantly affects subjects' decision to communicate after conviction. Columns three, four and five of

Table 5: Regression's results

	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)
Cumulated Earnings	0.144	0.140		
	(0.127)	(0.126)		
Fine	1.017*	0.778*	0.650	
	(0.548)	(0.431)	(0.412)	
Symmetry	0.780***	0.655***	0.668***	0.684***
	(0.265)	(0.197)	(0.196)	(0.193)
SymmXFine	-0.545			
	(0.768)			
Constant	-1.241***	-1.182***	-0.886***	-0.723***
	(0.347)	(0.337)	(0.200)	(0.165)
LogLikelihood	-452.397	-452.648	-453.268	-454.551
#obs.	692	692	692	692

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

the table present the estimation results for the reduced models obtained progressively deleting the factors the turned out not to be significant, according to loglikelihood-ratio tests at the standard 5% significance level.

Noticeably, even when the outcome of conviction is symmetric, only half of the convicted subjects decide to communicate again. Part of this effect is due to the fact that most of the collusive agreements had

Table 6: Communication rate when conviction outcome is symmetric

	rate of comm.	N. obs.
broken	46.13%	310
not broken	70.59%	102

been broken before they were detected: more precisely, if we restrict our attention to the cases in which conviction had a symmetric outcome, we still observe that in 76.22% of the detected cartels at least one member undercut the agreed upon price before detection took place. Some players therefore probabily decided non to communicate again because of a lack of trust that had already emerged before conviction. On the other hand, table 6 shows that even if the cartel had not been previously broken, still about 30& of the subjects chose not to communicate again. The number of observations is too small to make sound inference; nonetheless we believe that the behavior of these players could be explained with reference to availability heuristic: indeed, they behave as if the punishment recently experienced affected their perception of the level of risk of liability.

5 Conclusion

Our experiment shows that strategic risk, availability heuristic and saliency bias have important effects on cartel deterrence, though in general they are not taken into account in most of the theoretical analyses of low enforcement. This result, obtained through an explorative experiment – probably the first one in this field – calls for further, more specific experimental tests of the observed effects. A deeper and wider experimental evidence could then support the development of a theoretical analysis of cartel deterrence which incorporates strategic risk and the behavioral effects that have non-negligible effects according to our findings.

It would be also interesting to check whether our results are robust to a change in the framing of the experiment, so to see if our conclusions can be extended to other kinds of organized crime, such as corruption, fraud, auditor-manager collusion and corporate crime in general.

The interplay of rational considerations and behavioral biases in shaping deterrence of criminal activities deserves our attention and is a promising area for future research. While substantially more evidence is needed before drawing definitive theoretical conclusions, the glimpse that our study offers hopefully is a useful first step which will open the way for a rather new branch of experimental studies.

References

[1] Akerlof, G. Procrastination and obedience. *The American Economic Review 81*, 2 (1991), 1–19.

[2] Becker, G. Crime and punishment: An economic approach. *The Journal of Political Economy 76*, 2 (1968), 169–217.

[3] Blonski, M., Ockenfels, P., and Spagnolo, G. Co-operation in infinitely repeated games: Extending theory and experimental evidence, 2007.

[4] Blonski, M., and Spagnolo, G. Prisoners' other dilemma, June 2003.
http://www.wiwi.uni-frankfurt.de/Professoren/blonski/papers/PodRES.pdf.

[5] Cason, T., and Gangadharan, L. An experimental study of compliance and leverage in auditing and regulatory enforcement. *Economic Inquiry 44*, 2 (2006), 352.

[6] Dal Bó, P., and Fréchette, G. The evolution of cooperation in infinitely repeated games: Experimental evidence, October 2006.

[7] Eckel, C., and Grossman, P. Men, women and risk aversion: Experimental evidence. In *Handbook of Experimental Results*, C. Plott and V. Smith, Eds. Elsevier, New York, forthcoming.

[8] Fischbacher, U. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics 10*, 2 (2007), 171–178.

[9] Fishman, P., and Pope, D. G. Punishment induced detterence: Evidence from the video rental market, November 2006.
http://opimweb.wharton.upenn.edu/OPIM_Content_Management/OPIM_Files/Research_Files/2nd%20Paper%20-%20Pope.pdf.

[10] Folkes, V. The availability heuristic and perceived risk. *The Journal of Consumer Research 15*, 1 (1988), 13–23.

[11] Garoupa, N. Behavioral economic analysis of crime: A critical review. *European Journal of Law and Economics 15*, 1 (2003), 5–15.

[12] Harrington, W. Enforcement leverage when penalties are restricted. *Journal of Public Economics 37*, 1 (October 1988), 29–53.
http://www.sciencedirect.com/science/article/B6V76-458WNXV-3H/2/d3c35f75197b19adf3fbcd66920bae23.

[13] Holt, C., and Laury, S. Risk aversion and incentive effects. *The American Economic Review 92*, 5 (2002), 1644–1655.

[14] Jacquemet, N., Rullière, J., and Vialle, I. Monitoring optimistic agents. *Journal of Economic Psychology* (2007).

[15] Jolls, C. Behavioral law and economics, 2007.

[16] Jolls, C., Sunstein, C., and Thaler, R. A behavioral approach to law and economics. *Stanford Law Review 50*, 5 (1998), 1471–1550.

[17] Kahneman, D., Slovic, P., and Tversky, A. *Judgment Under Uncertainty: Heuristics and Biases.* Cambridge University Press, 1982.

[18] Kahneman, D., and Tversky, A. Prospect theory: An analysis of decision under risk. *Econometrica 47*, 2 (1979), 263–292.

[19] Keller, C., Siegrist, M., and Gutscher, H. The role of the affect and availability heuristics in risk communication. *Risk Analysis 26*, 3 (2006), 631–639.

[20] Levitt, S. Why do increased arrest rates appear to reduce crime: Deterrence, incapacitation, or measurement error? *Economic Inquiry 36*, 3 (1998), 353–72.

[21] Motta, M., and Polo, M. Leniency programs and cartel prosecution. *International Journal of Industrial Organization 21*, 3 (2003), 347–379.

[22] Polinsky, A., and Shavell, S. The economic theory of public enforcement of law. *Journal of Economic Literature 38*, 1 (2000), 45–76.

[23] Sapienza, P., Toldra, A., and Zingales, L. Understanding trust, 2007.

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

[25] Slovic, P., Finucane, M., Peters, E., and MacGregor, D. Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Analysis 24*, 2 (2004), 311–322.

[26] Spagnolo, G. Divide et impera: Optimal leniency programs. *SSRN eLibrary* (2004).