Incentive to squeal: an experiment on leniency programs for antitrust violations[*]

Benjamin Radoc[†]

Economist, Philippine Competition Commission

Philip Amadeus Libre

Consultant, Asian Development Bank

Shanti Aubren Prado

Consultant, World Bank Group

March 2020

[†]Corresponding author: `beradocjr@phcc.gov.ph`

Abstract

Competition authorities around the world have adopted leniency programs creating incentives for cartel members to come forward and provide information sufficient for cartel prosecution. We conducted a laboratory experiment simulating an infinitely repeated 4-player Bertrand game with homogeneous goods. The experiment allowed us to determine the effect of detection rate, penalty discount, and penalty rate on cartel formation and leniency application. Similar to past studies, we find that imposing a leniency program effectively deters cartel formation. However, surviving cartels quickly learn to cooperate. Leniency application is dependent on the immunity incentive (full penalty discount) and the risk of cartel detection, but not on the penalty rate.

Keywords: antitrust, cartel, experiment, leniency program

JEL Classifications: K210, L130, L44

1 Introduction

Illegal agreements among firms are highly profitable and difficult to detect. The formation and stability of a cartel is dependent on a long-term repeated interaction among market players. In addition to a degree of trust among cartel members, reputational considerations and credible threats preclude a member to deviate from an agreement. Knowledge on how cartel members react to risk of detection and the private incentives available to a member who decides to cooperate with a competition authority are useful in designing an effective leniency program (Spagnolo (2004)).

Competition authorities around the world have adopted leniency programs creating incentives for cartel members to come forward and provide information sufficient for cartel prosecution. Since the introduction of the US Corporate Leniency Policy for antitrust violations in 1978, other jurisdictions have implemented their own variants of a leniency program (Spagnolo (2008)). The antitrust law of the Philippines (Republic Act 10668 or the Philippine Competition Act) was enacted in 2015. Under Section 35 of the Philippine Competition Act, the Philippine Competition Commission is directed to "develop a Leniency Program to be granted to any entity in the form of immunity from suit or reduction of any fine which would otherwise be imposed on a participant in an anti-competitive agreement as provided in Section 14(a) and 14(b)... in exchange for the voluntary disclosure of information regarding such an agreement which satisfies specific criteria prior to or during the fact-finding or preliminary inquiry stage of the case." In other jurisdictions, although such leniency programs have led to the crackdown of cartels, it is unclear whether some designs are systematically better than others (Colino (2017)). This provides scope for experimental investigation.

Experimental evidence indicates that leniency programs are welfare-improving given the decline in average prices following leniency implementation. However, results on the impact of leniency programs on the extent of reporting and the stability of remaining cartels are mixed. In the study of Hinloopen and Soetevent (2008), participants played a repeated 3-player Bertrand game with homogeneous goods. Communication among participants was allowed but restricted to the revelation of each cartel member's minimum and maximum acceptable prices. In this setup, cartels were short-lived either due to the timing of a member reporting the cartel, or the immediate detection of the cartel activity by the competition authority. In comparison, Bigoni et al. (2012) allowed trade of heterogeneous goods in a 2-player duopoly Bertrand game with restricted communication. Fewer cartels were formed but those that remained persisted for many periods.

In another experiment, Dijkstra et al. (2011) allowed unrestricted direct communication in a repeated 2-player Bertrand game with homogeneous goods and examined the attractiveness of applying for leniency conditional on the probability of conviction, i.e. where few and profound investigations increase the probability of conviction. The high likelihood of detection led to more

cartels being reported. However, cartels that were created turned out to be stable amid unrestricted communication among cartel members.

We implemented an infinitely repeated 4-player Bertrand game[1] with homogeneous goods. The experiment was designed to determine the effect of detection rate, penalty discount, and penalty rate on cartel formation and leniency application.

Similar to Dijkstra et al. (2011), our experimental design allowed unrestricted (but time limited) communication. However, cartel members were allowed to report at any time during each round of the experiment, thus allowing the participants to outdo each other in terms of the timeliness of reporting. The probability of conviction was explicitly stated in terms of detection rate (ranging from zero to 50 percent). Penalties if caught were either 50 percent or 100 percent of own earnings in the current round, while the reduction in the penalty (discount) conditional on leniency application ranged from 50 percent to 100 percent of own earnings in the current round. Actual payoff at the end of the experiment was equivalent to a participant's average earnings in all the paid rounds. This strategy highlighted a player's incentive to cooperate and think of her stream of payoffs across the paid rounds, rather than on the one-time payoff from a randomly selected round.

Our results show that the different combinations of detection rate, penalty discount, and penalty rate deter cartel formation, but have a differential impact on leniency application. Although cartels are fewer, surviving cartels quickly learn to cooperate. The frequency of leniency application is rare and depends on the immunity incentive (full penalty discount) and the risk of cartel detection, but not on the penalty rate.

The rest of the paper is organized as follows: Section 2 discusses the theoretical model, Section 3 describes the experimental design, Section 4 lays down the hypotheses, Section 5 discusses the results, and Section 6 concludes with further discussion. The experiment instructions are provided at the end of the paper.

2   Model

The theoretical model described below is based on Motta and Polo (2003) and Dijkstra et al. (2011) which we use to derive predictions when there is an antitrust policy with a leniency program.

---

[1]Fonseca and Normann (2012) showed that the marginal benefit of communicating is maximized with 4 players relative to games with 2, 6, or 8 players. Also, Bos and Harrington (2010) argued that in the context of an infinitely repeated capacity-constrained price game, a necessary condition for any $(n-1)$ firms to meet competitive demand, if demand is linear, is that n must be greater than 3.

2.1 Basic Model

Four firms denoted by $N = 1, 2, 3, 4$ play a Bertrand game. Each firm i in N produces the same homogeneous product, has the capacity of producing a maximum of 50 units, and for simplicity supplies to consumers at zero production cost. The firms interact repeatedly over an infinite, discrete time horizon.

There are 120 consumers who each demand one unit of the good up to the reservation price of p^{max}=12. In each period, firms choose prices $p_i \in (1, 2, 3, \cdots, 15)^2$ simultaneously to maximize the present value of the profit stream with a common discount factor $\delta \in [0, 1)$. A firm's resulting profits for each round depends on one's own price choice and on the price chosen by her competitors. At the end of the experiment, the resulting profits is the average of the earnings in all the rounds.[3]

Each firm produces to meet demand up until its capacity. Consumers buy first from the firm offering the lowest price until its capacity has been exhausted. In case more than one firm charges the same low price, the firms equally share the quantity demanded.

2.2 Without antitrust

Absent the possibility of collusion, while there exist multiple Nash equilibria, our benchmark is the payoff dominant equilibrium in which all firms set a price of $p^N = 1$. This yields a competitive profit of $\pi^N = (120(p^N))/n = 120/4 = 30$. Thus, if firms play the competitive strategy in each period, the expected payoff of each firm is $V_N = \pi^N + \delta\pi^N + \delta^2\pi^N + \cdots = \pi^N/(1 - \delta)$.

However, firms can coordinate prices above the competitive level by forming a cartel. In each period, firms have to simultaneously decide if they want to form a non-binding cartel which consists of at least 2 firms (partial cartel). Firms then simultaneously select a price $p_i \in (1, 2, 3, \ldots, 15)$, but are not obliged to follow the agreed-upon price (if any) and therefore could subsequently undercut the cartel.

The joint profit maximizing price is the consumers' reservation price of $p^{max} = 12$, which yields a collusive profit of $\pi^C = (120p^{max})/n = 120(12)/4 = 360$. Thus, if firms collude in each period, the expected payoff of each firm is $V_C = \pi^C + \delta\pi^C + \delta^2\pi^C + \cdots = \pi^C/(1 - \delta)$.

A cartel member, however, might defect from the cartel arrangement. If a cartel member decides to do so, then it will optimally set a price that is slightly lower than the agreed-upon price (which in this case = 11). Given that each firm is capacity constrained at this price further lowering

---

[2]Prices above consumers' reservation price were included to identify players who either do not follow instructions or have the tendency to overprice.

[3]For simplicity, we assumed a discount factor equal to 1, which means that the weight attached to earnings is equal across the periods given that the time for rival firms to respond to an episode of defection is short.

the price is unprofitable. This is consistent with the model developed by Bos and Wandschneider (2014).

Assume that the formation of a cartel is sustained by means of a grim-trigger strategy where any deviation from the collusive price by a cartel member leads to each firm thereafter playing a static Nash equilibrium strategy. This implies that the deviating firm will gain a one-shot deviation profit of $\pi^D = 50(11) = 550$, followed by reversion to the competitive equilibria. Thus, the payoff associated with the unilateral deviation is: $V_{\mathrm{D}} = \pi^D + \delta\pi^N/(1-\delta)$.

2.3 Antitrust without leniency

Suppose that the competition authority may detect and prosecute collusion.[4] Assume that in each collusive period, the probability of being caught and punished is $\alpha \in (0, 1)$. If detected, each cartel member pays a fine of $F > 0$.

If all firms collude in each period, each firm will expect to earn the collusive profit π^C minus the fine F with probability α, and π^C with probability $(1 - \alpha)$. Thus, the expected payoff of each firm is $V_{\mathrm{C}} = \alpha(\pi^C - F) + (1 - \alpha)\pi^C + \delta V_{\mathrm{CR}} = (\pi^C - \alpha F)/(1 - \delta)$.

Consider a deviation. A cartel member who slightly undercuts the collusive price, will gain a one-shot deviation profit of π^D, and earn π^N in future periods. Thus, the payoff associated with the unilateral deviation is $V_{\mathrm{D}} = \alpha(\pi^D - F) + (1 - \alpha)\pi^D + \delta\pi^N/(1 - \delta) = \pi^D - \alpha F + \delta\pi^N/(1 - \delta)$.

2.4 Antitrust with leniency

Consider the case where colluding firms can apply for leniency without incurring any cost for reporting. Without any leniency applicant, the competition authority discovers and penalizes a cartel with probability α. With a leniency applicant, the competition authority discovers and penalizes a cartel for certain. Members of that cartel pay a fine $F > 0$.

Assume that only the first firm to apply obtains reduction of the penalty. Each member expects that the amount of discount it might receive due to leniency is given by $\theta \in [0, 1]$, which gives the percentage of penalty reduction for the first applicant. That is, the cartel member who first reports will pay a reduced fine equal to $(1 - \theta)F$. Following Motta and Polo (2003), assume further that a cartel that has been detected and prosecuted will immediately revert to its collusive behavior.

Collude and not report (CNR). If firms always play collude and not report, each firm will receive the collusive profit π^C in each period but will pay F with probability α. Thus, the expected payoff for playing *CNR* is $V_{\mathrm{CNR}} = \alpha(\pi^C - F) + (1 - \alpha)\pi^C + \delta V_{\mathrm{CR}} = (\pi^C - \alpha F)/(1 - \delta)$.

---

[4]This is presented here for completeness. In the experimental design, there is no treatment pertaining to antitrust without leniency.

Collude and report (CR). Suppose a firm participates in the collusion and then reports the cartel to the competition authority. This firm will receive collusive profit π^C less the reduced fine $(1 - \theta)F$ in the first period and earns competitive profits π^N in future periods. Meanwhile, the other cartel members will suffer the full fine F. Thus, expected payoff for *CR* is given by $V_{\text{CR}} = \pi^C - (1 - \theta)F + \delta\pi^N/(1 - \delta)$.

Consider a deviating firm that slightly undercuts the collusive price. This firm will gain a profit of π^D and a competitive profit π^N in future periods. Thus, the payoff associated with the unilateral deviation is $V_{\text{D}} = \alpha(\pi^D - F) + (1 - \alpha)\pi^D + \delta\pi^N/(1 - \delta) = \pi^D - \alpha F + \delta\pi^N/(1 - \delta)$.

3   Experimental Design

There are eight experiment conditions corresponding to combinations of detection rate, penalty discount, and penalty rate. For each treatment two sessions were conducted at the University of the Philippines (UP). Each session had 12 to 28 participants and lasted for 45 to 60 minutes. The computer experiment was programmed in Python and implemented in oTree (Chen et al. (2016)).

Each treatment consisted of two Parts. In Part 1, participants were randomly grouped into 4 (representing 4 equally sized firms) and played 5 practice rounds with the same group to help them become familiar with the tasks. After the practice rounds, each participant was again randomly grouped with 3 other players; grouping was maintained throughout Part 2. Each participant knew that her actual earnings at the end of the experiment was the average of her earnings per round in Part 2 plus a participation fee of PHP 100. Participants also knew that Part 2 may end at any round.

In Part 1, each participant was a seller who had access to 50 trinkets which could be sold at an offer price ranging from PHP 1 to PHP 12. Total supply at each round was 200 trinkets, but there were only 120 consumers who may buy only 1 trinket each per round at a maximum price of PHP 12. After all group members have submitted their offer price, consumers start buying trinkets starting from the lowest price until all the 120 lowest-priced trinkets were purchased. If participants in a group had the same offer price, a proportional rule was applied. For example, if one participant has sold all her 50 trinkets and the other 3 participants in the group had the same but higher offer price, they equally share the residual demand.

Before choosing an offer price, a participant had the opportunity to interact with members of her group but with only those who had decided to use the time-limited chat window. Use of the chat window to discuss their offer price was free of charge. At the end of each round, the computer displayed the details of each group member's earnings. Throughout the experiment, participants had access to an on-screen calculator, a pen and paper which most participants used to track prices and earnings.

The tasks in Part 2 were similar to Part 1. The participants knew that the actual number of

Rounds will be randomly determined by the computer so that Part 2 may end at any time. In each round, participants decided whether to use the chat window to communicate with other players to agree on an offer price. However, in Part 2 participants knew that communicating through the chat window, regardless of the price agreement reached, may be penalized. If detected by the computer, the fine is equal to half of a player's earnings in the current round. In the experiment, a (partial) cartel was formed if at least 2 of the 4 participants decided to chat. A cartel participant had the opportunity to either avoid or reduce the penalty of detection if she succeeds as the first player (or marker) in her group to report the use of the chat window by clicking on a report button on-screen. This action of self-reporting is similar to applying for leniency to a competition authority. The first marker in a group was shown a message that she was the first to self-report for that round, while other markers saw a message stating that another participant has previously applied for leniency. At the end of each round, the computer displayed the details of each group member's gross earnings, penalties, and net earnings. This means that if at least one participant self-reported, it is possible for members of a group to determine which player is the first marker.

4 Hypotheses

Hypothesis 1. Offer prices tend to be lower in the *no chat* condition relative to other conditions where players have an opportunity to coordinate with other players. The strategy to collude strongly dominates the strategy to compete independently and this is more pronounced when there is no possibility of penalty for coordinating.

Hypothesis 2. V_C decreases as the detection rate increases, *ceteris paribus*. Cartels are more likely to form and prices will be higher under reduced discount ($\alpha = 15\%$), followed in decreasing magnitude by high detection ($\alpha = 30\%$) and higher detection ($\alpha = 50\%$). Thus, controlling for the level of leniency discounts, higher detection rates make the formation of cartels less likely.

Hypothesis 3. $V_C > V_N$ for *any* value of θ, or penalty F. A cartel is likely to be formed regardless of the extent of penalty.

Hypothesis 4. Cartels will be stable. Firms always have an incentive to collude across all treatments since $V_C > V_D$. The value of defection V_D, however, decreases as the detection rate increases, *ceteris paribus*. That is, the number of deviations from the collusive price is highest under reduced discount ($\alpha = 15\%$), followed in decreasing magnitude by high detection ($\alpha = 30\%$) and higher detection ($\alpha = 50\%$). Also, the V_D decreases as the extent of penalty increases, *ceteris paribus*; deviations are less likely under full penalty ($F = 100\%$) than under immunity ($F = 50\%$).

Hypothesis 5. There is no self-reporting regardless of the detection rate α, since $V_{CNR} > V_{CR}$. The value of colluding and not reporting is highest under reduced discount ($\alpha = 15\%$), followed in decreasing magnitude by high detection ($\alpha = 30\%$) and higher detection ($\alpha = 50\%$). *Hypothesis*

6. There will be no self-reporting regardless of the extent of penalty, since $V_{CNR} > V_{CR}$ at various levels of *F*. The value of colluding and not reporting is higher under immunity ($F = 50\%$) than under full penalty ($F = 100\%$).

Hypothesis 7. There is no self-reporting regardless of the level of leniency discounts, since $V_{CNR} > V_{CR}$ at various levels of θ. Hence, cartel members always have an incentive to keep mum about the cartel. Controlling for detection rate, such incentive is high under reduced discount ($\theta = 50\%$) followed in decreasing magnitude by leniency ($\theta = 80\%$) and immunity ($\theta = 100\%$).

5 Results

The experiment was participated in by university students who pre-registered online. The 232 participants were either advanced university undergraduate students (71%) or postgraduate students (29%).[5] Maximum possible earnings during the experiment is PHP 700 (USD 13.4). Range of actual earnings is PHP 100 (USD 1.9) to PHP 605.56 (USD 11.6), with a mean of PHP 265.27 (USD 5.1) and standard deviation of PHP 87.97 (USD 1.7). Mean age is 23 years, with range of 19 to 47 years; 59% are females.

Table 1 summarizes the eight treatments we conducted, corresponding to combinations of (i) *detection rate* or probability of detection as proxy for a competition authority's reputation and/or experience in cartel prosecution; (ii) *penalty discount* or reduction in fines conditional on the status of the cartel investigation, i.e. higher incentive for firms that come forward early on, and lower reduction for leniency applicants at a later phase of a cartel investigation; and (iii) *penalty rate* as a fraction of current-round earnings.

In the *no chat* condition, direct communication among group members is not possible. The *chat with no penalty* condition is a laissez-faire market, while the other treatments correspond to different *leniency* conditions with varying combinations of detection rate, penalty discount, and penalty rate.

Result 1: Offer prices are significantly lower when participants have no opportunity to directly communicate.

In the *chat with no penalty treatment*, average offer price covering all rounds (practice rounds in Part 1 and actual rounds in Part 2) is 9.27 (SD=2.58), twice the average offer price of 4.63 (SD=2.93) in the *no chat treatment*. The difference is statistically significant based on the Wilcoxon ranksum test (z=-18.924, p=0.0000). In the actual rounds, the divergence in offer prices is 2.7 times

---

[5]The experimenters opted to recruit only advanced university students on the assumption that younger students are less cunning or less likely to participate in organized crime. 23% of the participants revealed that they have engaged in betting in the past 6 months, 10% of participants do not feel constrained to engage in illegal behavior and 41% are likely to violate rules if the probability of detection is low.

Table 1: Summary of experiment treatments

Condition (in %)	Detection Rate	Penalty	Fine Reduction
No chat	NA	NA	NA
Chat with no penalty	0	0	NA
Immunity (partial penalty)	15	50	100
Immunity (full penalty)	15	100	100
High discount	15	50	80
Low detection	15	50	50
High detection	30	50	50
Higher detection	50	50	50

larger (z=-20.781, p=0.0000). When participants have no opportunity to directly communicate average offer price is 3.47 (SD=2.15); when participants are allowed to communicate with no risk of penalty, offer price is 9.36 (SD=2.62).

Figure 1 shows the distribution of offer prices across the rounds. With no opportunity to communicate, offer prices in the no chat treatment quickly declined in Part 2 of the experiment, starting from an average of 7.14 down to 2.89 by round 15. Also, the range in offer prices is narrower in the no chat treatment, as shown by the distance between the largest non-outlier (top whisker) and smallest non-outlier (bottom whisker).

In contrast, the pattern in offer prices in the no penalty treatment suggests learning among the participants. The initial decline in offer prices reversed in later periods. In Part 2, starting from an average of 10.13, offer prices dipped to 8.71 by round 6 but reverted back to 10.21 by round 10. Participants' realization that payoffs are higher with cooperation is apparent in the recorded chats.[6]

Result 2: Cartel formation is prevalent but risk of detection serves as a significant deterrent.

In the experiment, a cartel is formed in a round when at least two players in a group use the chat window to communicate and discuss a common offer price. In the 7 experimental conditions where group chat is allowed (see Table 2, on average only 83% of the participants agreed to use the chat window in Part 1 even without the risk of detection.

In Part 2 of the experiment, there is a known probability that the computer may detect the group's use of the chat window. Detection means that users of the chat window are subject to a

---

[6]Based on the recorded conversations, users of the chat window initially could not agree on the maximum offer price of 12 because either not all group members were in the chat or at least one group member was silent. As the experiment progressed, lower earnings prodded at least one group member to suggest the need to cooperate. Here is a sample message culled from one of the recorded chats: "Player 1: I'm serious we can maximize our profit if we choose to stick with a steady price. Usually games like this max payoffs if cooperation is done."
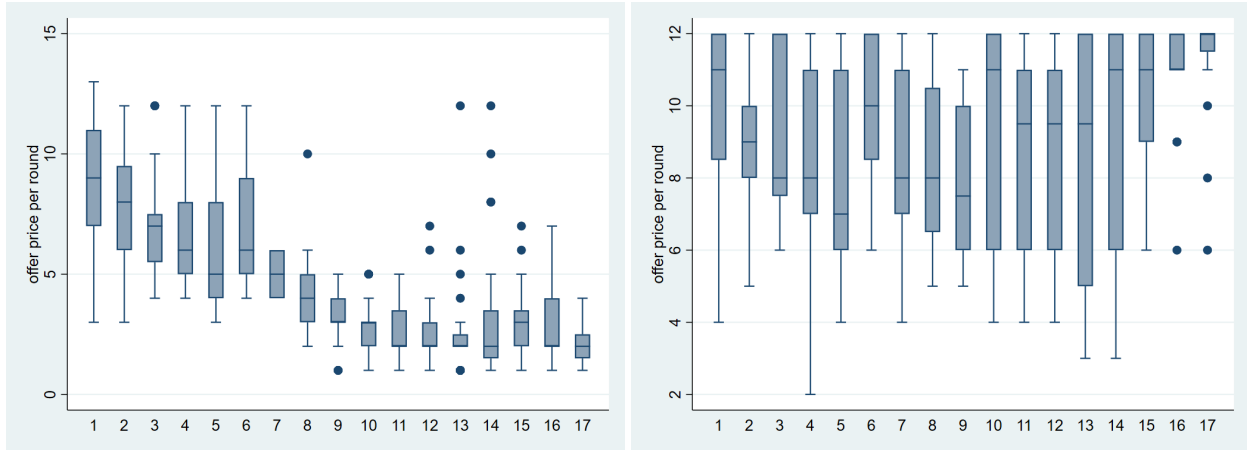
Figure 1: Distribution of offer prices per round in the *no chat condition* (left) and the *chat with no penalty condition* (right). On average, offer prices are significantly lower in the no chat condition relative to the chat condition. The gap in the offer prices also widens over time as participants in the no chat condition undercut each other.

penalty equivalent to a fixed percentage of earnings in the current round. Controlling for penalty (fixed at 50% of earnings), the data suggest that the use of the chat window is lower as the detection rate increases ($\rho = -0.2011, p = 0.0000$). Comparing the treatments, the Wilcoxon ranksum test results reveal that the fewer number of cartels formed in Part 2 is statistically different between the *low detection* and *higher detection* treatments (z=-2.688, p=0.007) and between the *high detection* and *higher detection* treatments (z=-6.268, p=0.000), but not between the *low detection* and *high detection* treatments (z=-1.466, p=0.142) treatments.

Table 2: Chat window use and deviation from agreed common price (in %)

Treatment	Part 1 (% of players)		Part 2 (% of players)	
	users of the chat window	engaged in undercutting	users of the chat window	engaged in undercutting
Chat with no penalty	80.0	16.7	89.6	9.0
Immunity (partial penalty)	86.7	15.0	18.1	3.5
Immunity (full penalty)	80.0	5.0	28.6	1.6
High discount	89.5	11.4	21.8	0.6
Low detection	79.4	11.1	35.0	3.0
High detection	73.1	7.5	18.0	0.5
Higher detection	90.8	15.8	15.6	1.4

Result 3: A cartel is likely to form regardless of the penalty rate.

11

If a cartel is formed in a round, a fraction of the earnings in the current round may be deducted from the earnings of chat window users. Refer to Table 2. We compare the impact of penalty rate using 3 treatments controlling for detection rate (fixed at 15%): *no penalty* (0%), immunity with *partial penalty* (50%), and immunity with *full penalty* (100%).

Imposing a possible penalty deters cartel formation. In Part 2 of the experiment, the use of the chat window is significantly lower in the immunity with partial penalty (z=11.455, p=0.0000) and in the immunity with full penalty treatments (z=10.290, p=0.0000) compared to the no penalty condition.

However, cartel formation is not reduced to zero. On average 18% of participants in the immunity with partial penalty continued to use the chat window in Part 2, and (29%) did so in the immunity with full penalty condition. In the recorded conversations, no one mentioned the size of the penalty, even in the condition where there is risk that total earnings in a round may be reduced to zero. We note however that this may be an artefact from the experimental design, given that participants know that actual earnings in the experiment is the average payoff in Part 2 rather than the earnings in one randomly selected round.

Result 4: Cartels tend to stabilize more quickly in the presence of a leniency program.

Even with direct communication, a participant may defect if she used the chat window together with at least one other participant and agreed on a common offer price but the actual offer price in that round is lower than the agreed common price. A cartel may be unstable if undercutting or defection is prevalent. By definition, a cartel is considered stable if abiding by the collusive agreement is the optimal strategy for all firms (Harrington (2008) so that deviating from the agreed offer price may yield higher earnings in the current round, but future earnings may be lower if as a result of the deviation participants within a group continue to undercut each other in succeeding rounds.

Although deviation from the agreed common price was not uncommon, our results suggest that participants eventually learned to cooperate. In all the experiment treatments where the chat window is available, 11.8% of participants in Part 1 attempted to offer a price lower than the agreed price. In Part 2, undercutting declined to 2.8% on the average. And in later rounds, undercutting disappeared as participants realized that cooperation can raise their average earnings.[7]

In the chat with no penalty treatment, undercutting continued until the end of the experiment. On average, 9% of players deviated from the agreed offer price. In contrast, we find that in the leniency conditions on average 1.8% of players engaged in undercutting, but the number of defectors were down to zero by the third round of Part 2. All the Wilcoxon ranksum test results comparing chat with no penalty with each of the leniency program options confirm that undercutting in Part

---

[7]Here are two sample messages: (1) Player 1: Let's stick to 12. Player 2: No talkshit so we all go home with moolah. Player 4: Game! (2) Player 3: Last chat? Player 4: Yes, 12 all the way! Player 2: Copy.

2 is significantly lower with leniency. This pro-collusive effect of leniency is consistent with the results of Bigoni et al. (2012).

Result 5: The rate of self-reporting or leniency application is higher than the model's prediction.
Since the payoff from colluding and not reporting the cartel (V_{CNR}) is larger than the earnings from colluding and reporting (V_{CR}), the theoretical model in Section 2 predicts that no cartel member (or user of the chat window) will apply for leniency, regardless of (i) the risk of detection (detection rate), (ii) the extent of penalty (% reduction in current round earnings), and (iii) reduction in penalty as reward for reporting (penalty discount).

Our data show that self-reporting happened at least once in 11 out of the 43 groups with the opportunity to apply for leniency (by clicking on the report button on the computer screen). 7.7% of the participants applied for leniency. Of the 45 leniency applicants, 26 players succeeded as first marker and received reduced penalty in the round where they self-reported.

We examined all instances where at least one cartel participant self-reported. 44% of the self-reporting happened in the early rounds of Part 2 where undercutting was apparent despite a commonly agreed offer price. Retaliation Hinloopen and Soetevent (2008) was not the only motivation behind self-reporting. In half of the self-report cases, participants used the chat window but no agreement was reached and resulted in low earnings for the period. However, frustration and retaliation among the groups which self-reported was short-lived. Repeated self-reporting occurred in only 1 group: starting average offer price in Part 2 was 9.50; the ending average offer price was reduced to 4.75. In the other groups, participants typically sent repeated reminders not to report. In cases where at least one participant self-reported, the group was easy to forgive conditional on the promise never to self-report again.[8]

The actual self-report rate deviates from the theoretical model's prediction of zero. However, self-reporting within a group was commonly a one-time occurrence as participants learned to cooperate. This is not surprising given the effect of self-reporting in an infinitely repeated game. As Bigoni et al. (2012) suggested, self-reporting destroys trust among players and limits cooperation in succeeding periods. This realization is confirmed in the content of the recorded chats. Constant reminders within groups not to report was also common.[9] Table 3 compares the frequency of self-reporting across the leniency treatments.

Self-reporting rate is highest under the immunity condition with partial penalty, where a first marker avoids the certain 50% reduction in current-round earnings. Note however that immunity with a potential higher penalty (at 100% of earnings in the current round) does not result in a higher

---

[8]Here is a sample chat. Player 1: OMG what happened? I was caught. Player 2: Me too. Player 3: It's OK. 50% of 0 is 0. Haha. Player 1: Don't report again. Find the good in you.

[9]Here are two examples. (1) Player 1: Stick to 12? Player 2: Yes, just don't report. Player 1: Agreed. (2) Player 4: There is penalty. Player 2: Yes 15% though, so don't report. Player 3: Agree. How unlucky can we be? Hahaha.

Table 3: Leniency application

Treatment	Applicants	Report Rate (%)	Wilcoxon ranksum test
Immunity (partial penalty)	5	19.2	
Immunity (full penalty)	16	7.6	z=2.429, p=0.0151
High discount	4	3.8	z=2.301, p=0.0214
Low detection	13	9.5	z=2.314, p=0.0207
High detection	2	3.3	z=2.006, p=0.0448
Higher detection	5	12.2	z=1.003, p=0.3157

leniency application rate.

Controlling for the penalty rate (fixed at 50%), we find that leniency application is significantly higher when the likelihood of cartel detection is high (at 50%). The Wilcoxon ranksum test results also indicate that there is no significant difference in leniency application between immunity with partial penalty and the higher detection condition. This suggests that the reputation of a competition authority in cartel prosecution may influence the decision to either apply or not apply for leniency.

6 Concluding remarks

The introduction of an antitrust regime with a leniency program, regardless of detection rate or extent of discount on penalty, deters cartel formation. Among the combinations of detection rate, extent of penalty, and discount rates, self-reporting is highest when penalty is reduced to zero (immunity) and when the probability of detection is high.

In addition to the experiment, we conducted a series of focus group discussions with members of chambers of commerce and law practitioners in the Philippines to determine other variables that may influence leniency application. The qualitative data gathered confirm that immunity from penalty and the probability of detection determine the likelihood of self-reporting.

Specific considerations are: criminal immunity given risk of being identified as ring leader, high probability of cartel detection especially if the competition authority has opened an investigation and identified parties that are potentially liable, certainty of being a first marker given risk of self-incrimination, and the pace of judicial proceedings.

References

Maria Bigoni, Sven-Olof Fridolfsson, Chloé. Le Coq, and Giancarlo Spagnolo. Fines, leniency and rewards in antitrust. *RAND Journal of Economics*, 43(2):1756–2171, 2012.

Iwan Bos and Joseph E. Jr. Harrington. Endogenous cartel formation with heterogeneous firms. *RAND Journal of Economics*, 41(1):92–117, 2010.

Iwan Bos and Frederick Wandschneider. A note on cartel ringleaders and the corporate leniency programme. *Applied Economics Letter*, 20(11):1100–1103, 2014.

Daniel L. Chen, Martin Schonger, and Chris Wickens. o-tree - an open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance*, 9:88–97, 2016.

S. Marco Colino. The perks of being a whistleblower: Designing efficient leniency programs in new antitrust jurisdictions. *Vanderbilt Journal of Transnational Law*, 50(5):535–582, 2017.

Peter Dijkstra, Marco Haan, and Lambert Schoonbeek. Leniency programs and the design of antitrust: Experimental evidence with unrestricted communication. 07 2011.

Miguel A. Fonseca and Hans-Theo Normann. Explicit vs. tacit collusion: the impact of communication in oligopoly experiments. *European Economic Review*, 56:1759–1772, 2012.

Joseph Harrington. *Handbook in Antitrust Economics*, chapter Detecting Cartels. MIT Press, 2008.

Jeroen Hinloopen and Adriaan R. Soetevent. Laboratory evidence on the effectiveness of corporate leniency programs. *RAND Journal of Economics*, 39(2):607–616, 2008.

Massimo Motta and Michele Polo. Leniency programs and cartel prosecution. *International Journal of Industrial Organization*, 21(3):347–379, 2003.

Giancarlo Spagnolo. Divide et impera. optimnal deterrence mechanisms against cartels and organized crime. 09 2004.

Giancarlo Spagnolo. *Leniency and Whistleblowers in Antitrust*, chapter 7, pages 259–303. MIT Press, Cambridge, Massachusetts, 2008.

7 Appendix

7.1 Instructions (Part 1)

Welcome to today's experiment on decision-making. Please fill in the consent form on your desk.

Turn off your mobile phones and other devices, as they may not be used during today's session. Refrain from talking to other participants during the experiment. If you have a question, please raise your hand and one of the experimenters will come and answer it privately.

Each of you will earn PHP 100 for participating in today's session. You will have the opportunity to earn an additional amount of money which will depend on a series of decisions you will make and the decisions of other participants. You will receive your earnings privately before you leave today.

This experiment has two Parts. Part 1 consists of 5 practice rounds to help you become familiar with the computer screens. In Part 2, the actual number of Rounds will be randomly determined by the computer. Only your earnings in Part 2 will be paid to you in cash. Your actual earnings in this experiment will be your average earnings in Part 2 plus a show-up fee of PHP 100. We will describe your tasks in Part 2 after we complete Part 1.

YOUR TASKS

In this experiment, you will play the role of a seller. In every Round, you will have access to 50 trinkets. You will decide at what offer price, ranging from PHP 1 to PHP 15, you are willing to sell all your trinkets.

At the beginning of Part 1, the computer will randomly group you with 3 other participants in this room or in the other room. They will be the same people you will encounter throughout Part 1.

In every Round, there are 200 trinkets that are available for sale. However, there are only 120 consumers who buy only 1 trinket each per Round at a maximum price of PHP 12. This means that it is not possible for all 4 members of your group to sell all their trinkets.

CHAT WINDOW

For each Round, you will have the opportunity to interact within your group before choosing your offer price. If you choose to communicate, a chat window will be available for 60 seconds. You may discuss your offer price but you are not allowed to reveal your identity, your location in the room, or any other personal information about yourself.

YOUR SALES

After the chat window closes, you will select your offer price. After everyone has submitted their offer price, consumers will start buying trinkets starting from the lowest price until all the 120

lowest-priced trinkets are purchased.

If participants in your group have the same offer price, a proportional rule will be applied. For example, when one participant has sold all 50 trinkets and if the other 3 participants in the group have the same but higher offer price, they will each sell 23 trinkets.

At the end of each Round, the computer will display the details of your earnings and the earnings of the other participants in your group. Refer to the sample screen below.

<div align="center">

You are playing Part 1. In practice Round 1

</div>

Player 1 (you) would have earned PHP 500,	having sold 50 trinkets at an offer price of PHP 10
Player 2 would have earned PHP 420,	having sold 35 trinkets at an offer price of PHP 12
Player 3 would have earned PHP 420,	having sold 35 trinkets at an offer price of PHP 12
Player 4 would have earned PHP 0,	having sold 0 trinket at an offer price of PHP 15

At any time during the experiment, you will have access to a calculator displayed on your computer screen. An extra sheet of paper is also on your desk which you may use for note taking.

If you have a question, please raise your hand and one of the experimenters will come and answer it privately.

If you have no question, please click on the button labelled "Next" that appears on your screen. You will see a series of questions that you need to answer correctly. You may refer back to these instructions at any time during the experiment.

7.2 Instructions (Part 2 - immunity treatment with partial penalty)

In Part 2, you have the opportunity to earn an additional amount of money equal to the average of your earnings per Round. The actual number of Rounds will be randomly determined by the computer. This means that Part 2 may end at any time but will not last for more than 30 minutes.

YOUR TASKS

Your tasks in Part 2 are similar to your tasks in Part 1. In every Round, you will have access to 50 trinkets. You will decide at what offer price, ranging from PHP 1 to PHP 15, you are willing to sell all your trinkets. In every Round, there are 200 trinkets that are available for sale. However, there are only 120 consumers who buy only 1 trinket each per Round at a maximum price of PHP 12. This means that it is not possible for all 4 members of your group to sell all their trinkets.

The computer will again randomly group you with 3 other participants in this room or in the other room. It is possible that the participants you will encounter in Part 2 may be the same as or may be different from the participants you encountered in Part 1. However, they will be the same people you will encounter throughout Part 2.

CHAT WINDOW

For each Round, you will have the opportunity to interact within your group before choosing your offer price. If you choose to communicate, a chat window will be available for 60 seconds. You may discuss your offer price but you are not allowed to reveal your identity, your location in the room, or any other personal information about yourself.

YOUR GROSS EARNINGS

Towards the end of each Round, the computer will display the details of your earnings and the earnings of the other participants in your group. Refer to the sample screen below.

You are playing Part 2. In Round 3

Player 1 (you) earned PHP 300,	having sold 30 trinkets at an offer price of PHP 10
Player 2 earned PHP 300,	having sold 30 trinkets at an offer price of PHP 10
Player 3 earned PHP 300,	having sold 30 trinkets at an offer price of PHP 10
Player 4 earned PHP 300,	having sold 30 trinkets at an offer price of PHP 10

PENALTY

In Part 2, the computer is programmed to partially detect your use of the chat window. At the end of every Round, there are 15 out of 100 chances (or 15 percent) that the computer will detect your use of the chat window. If the computer detects your use of the chat window, you will pay a penalty equal to 50 percent of your earnings in the current Round.

You will have the opportunity to avoid the possible penalty by reporting that your group used the chat window in the current Round. To report, click on the button labelled "Report" located on the upper-right-hand corner of the screen.

Refer to the sample screen below.
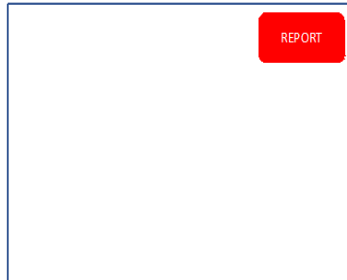
In every round, the first participant in your group who clicks on the button labelled "Report" shall not pay any penalty. The other users of the chat window will pay the full penalty.

Let us consider an example. Imagine that you are in Round 3. All participants in your group used the chat window and earned PHP 300 each. Below are two scenarios.

Scenario	Penalty in Round 3
(1) No one in your group clicked on the "Report" button in Round 3	• If the computer detects (with 15% chance), all users of the chat window pay a penalty of PHP 150 (or 50% of PHP 300) • If the computer does not detect, all participants pay zero penalty
(2) Someone in your group clicked on the "Report" button in Round 3	• The first person who clicked on the "Report" button for sure pays zero penalty • The other users of the chat window for sure pay the full penalty of PHP 150.

YOUR NET EARNINGS

At the end of each Round, the computer will display your earnings and all penalties, if any. Refer to the sample table below.

At any time during the experiment, you will have access to a calculator displayed on the computer screen. An extra sheet of paper is also on your desk which you may use for note taking.

You are playing Part 2. In Round 3

	Gross earnings	Penalty	Net earnings
Player 1	_____	_____	_____
Player 2	_____	_____	_____
Player 3	_____	_____	_____
Player 4	_____	_____	_____

Remember that your actual earnings in this experiment will be your average earnings in Part 2 plus a show-up fee of PHP100.

If you have a question, please raise your hand and one of the facilitators will come and answer it privately. If you have no question, please click on the button labelled "Next".