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How much you talk matters: cheap talk and collusion in a Bertrand oligopoly game

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Abstract

This study investigates the impact of cheap talk on price in a repeated Bertrand oligopoly experiment. Each participant plays 20 rounds. Participants are placed in three-person bidding groups where the lowest bid wins. During the first 10 rounds, participants are not allowed to communicate with each other. All three-person groups converged to the zero-profit equilibrium in the first 10 periods. We then play another 10 rounds where participants can text with one another using an instant message system. Some groups were allowed to text before every round, some to text before every other round, some to text every third round, some to text every fourth round, and some to text only every fifth round. When texting is allowed, All groups attempt to collude to raise the price after being allowed to text, but the only groups who can maintain the higher price and converge over time to the joint-profit maximum are the groups who can text before every period. Hence, cheap talk is only effective when subjects can continuously monitor or converse.

Keywords

Bertrand Competition, Experiments, Collusion, Cheap Talk, Amazon Mturk

Disciplines

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How much you talk matters: cheap talk and collusion in a Bertrand oligopoly game

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Abstract

This study investigates the impact of cheap talk on price in a repeated Bertrand oligopoly experiment. Each participant plays 20 rounds. Participants are placed in three-person bidding groups where the lowest bid wins. During the first 10 rounds, participants are not allowed to communicate with each other. All three-person groups converged to the zero-profit equilibrium in the first 10 periods. We then play another 10 rounds where participants can text with one another using an instant message system. Some groups were allowed to text before every round, some to text before every other round, some to text every third round, some to text every fourth round, and some to text only every fifth round. When texting is allowed, All groups attempt to collude to raise the price after being allowed to text, but the only groups who can maintain the higher price and converge over time to the joint-profit maximum are the groups who can text before every period. Hence, cheap talk is only effective when subjects can continuously monitor or converse.

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JEL Classification: C7, C92, K21, L41

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1. Introduction

Collusion is cooperation that reduces competition in markets. Collusion may harm consumers if colluders are able to keep prices above the competitive equilibrium prices: it may harm competitors if colluders are able to keep other firms from entering markets. Laws such as the Sherman Antitrust Act of 1890 were passed during a period of increasing monopoly power. For example, John D. Rockefeller was building the Standard Oil Trust by buying up oil rights and small oil companies in order to control the burgeoning oil market (McGee, 1958). While economists generally agree that a true monopoly, such as the Standard Oil Trust, may be able to raise prices and earn monopoly profits, there is debate about how many firms are required for competition and whether trade organizations that encourage "cheap talk" among competitors are anti-competitive (Farrell, 1987; Huck et al., 2004; Horstmann et al., 2018).

We offer experimental evidence on cheap talk in a repeated Bertrand oligopoly competition. Each participant can text with two other participants using an instant message system. We first run groups of three subjects through 10 rounds of pricing without allowing cheap talk communication. For the second ten rounds we allow some subjects to text before every round, some to text before every other round, some to text every third round, some to text every fourth round, and some to text only every fifth round.

We find that all three-person groups converge to the zero-profit equilibrium in the first 10 periods, when no texting is allowed. On average, all groups attempt to collude to raise the price after being allowed to text, but the only groups who can maintain the higher price and converge over time to the joint profit maximum are the groups who can text before every period for the second set of 10 periods. This is an important new finding about the value of cheap talk. It is only effective when subjects can “continuously monitor” or check in with one another before each pricing decision.

In addition, the more participants discuss the price, the higher the price, and their choices significantly affect the market price (winning price). However, participants or groups who criticize each other a lot tend to name lower prices and the behavior affects winning prices. The impact of individual characteristics on price selection is also notable. On average, women choose lower prices than men do, but their pricing behavior does not significantly affect the market price. Participants with higher educational achievement choose higher than those with lower educational achievement, but their pricing differences do not significantly affect the market price. On the other hand, older participants tend to choose lower prices than younger participants, but their pricing choices do not significantly affect market prices.

The remainder of this paper proceeds as follows. **Section 2** presents and summarizes the previous articles related to this topic. **Section 3** describes how we design the experiment. **Section 4** describes the way we collect the data, the characteristics of the data, and an in-depth analysis of the data. **Section 5** describes significant findings on pricing behavior. The final section offers some concluding statements.

2. Literature Review

There are three main channels of how communication supports collusion (Fonseca and Normann, 2012). Communication helps firms coordinating on a price, removes strategic uncertainty, and helps with conflict-mediation to avoid a decline in price. Various forms of talking may facilitate price cooperation. The condition of sustaining collusion is satisfied when there is a comprehensive discussion of prices firms will charge, and when there is an adequate punishment for noncompliance with pricing agreements (Cason, 2008). In our setting, we use cheap talk, which consists of costless, nonbinding, and non-verifiable messages that may affect listeners' beliefs. Farell and Rabin (1996) stress that cheap talk helps to avoid misunderstandings and coordination failures; it often improves the outcomes of sellers. Even though there are no direct payoff implications in firms' cheap talk conversations, they may convey some meaning in equilibrium.

Many papers report that companies attempting to coordinate on price meet regularly in real life (Genesove and Mullin, 2008; Harrington, 2006). These authors point out that meetings among competing firms often lead to cooperation. These meetings allow firms to maintain observably higher prices for long periods of time. The observation that some companies succeed in raising prices after meeting with one another encourages other companies to meet to discuss prices and monitor compliance with previously discussed prices (Awaya and Krishna, 2016). Firms meeting to discuss pricing and compliance pose a problem for social welfare and efficiency. Firms are assumed to be able to keep prices above competitive equilibrium prices and quantities of goods and services sold below competitive equilibrium quantities. The combination of higher prices and lower quantities imposes a dead-weight loss on the market, reducing efficiency (Posner, 1975; Fisher, 1985; Charness, 2000).

Previous experiments using other games have shown that communication leads to cooperation. Some papers show the impact of communication in a repeated double auction, posted offer, and sealed bid-offer market (Isaac and Plott, 1981; Isaac et al., 1984; Isaac and Walker, 1985). These studies find that subjects may be able to attain higher profits for some periods (collusion), but subjects are not able to sustain those higher profits with repetition. Other papers consider the repeated Hotelling model (coordination on profit-maximizing location differences). Brown-Kruse et al. (1993) and Brown-Kruse and Schenk (2000) study Hotelling competition with written communication and report that cheap talk allows participants to earn higher profits.

Crawford (1998) summarizes experimental evidence on communication. He concludes that cheap talk is a useful device for firms with repeated interactions to collude on pricing. Holt and Davis (1990) use restricted messages and show that nonbinding communication can assist firms in raising prices above the competitive equilibrium in posted-offer markets. The messages are restricted to price and either agreement or disagreement. Sellers can only write down prices and buyers have to choose between agreeing and disagreeing with the posted prices. Cason (1995) also studies the potential market impact of non-binding price signals on prices in posted-offer markets. He finds that price signals increase market prices in some circumstances but lose their impact over time. Cason (2008) finds that increasing the number of communication rounds increases the likelihood prices will remain above the competitive market equilibrium price.

There are a number of studies of Bertrand competition with communication. Using a Bertrand duopoly design, Andersson and Wengström (2007) find that costly communication decreases the number of messages but enhances the stability of collusive agreements compared to no-cost communication. Fonseca and Normann (2012) focus on the effect of the number of firms on price in repeated Bertrand oligopolies. Although their goal is to show a negative relationship between the number of firms and collusive prices, they also find that texting allows firms to set higher prices.

Some studies focus on free-style communication (Charness and Dufwenberg, 2006; Goeree and Yariv, 2011; Agranov and Tergiman, 2014). However, to our knowledge, there is no systematic study of how much free-style communication is required to maintain price collusion. This paper studies repeated Bertrand Oligopoly competition using an instant message system that allows participants to send messages without any limitation. We vary the frequency of communication allowed. Furthermore, this paper uses Amazon Mechanical Turk subjects (MTurk) via the oTree platform (Chen et al., 2016). Most prior experiments above focused on laboratory settings with undergraduates, whose decisions and interactions may be different from adults in the general public.

3. Experimental Design

3.1 Outline of Experiment

We examine Bertrand oligopoly markets with inelastic demand and a constant marginal cost of production (Holt et al., 1986). Participants are placed in groups of three according to their arrival times. Each participant is endowed with one unit of a hypothetical good each period. The goal each period is to sell each unit at the highest possible price in an auction where the lowest price wins. Each participant privately sets her or his price between 0 and 100. The lowest price in the group wins, and the participant who names the lowest price earns that price as private profit. In the case of a tie for the lowest price, the profit is evenly divided among those naming the lowest price. The goal of each participant is to earn the highest possible profit. Since each participant earns either the lowest price (possibly shared) or 0 as profit, the incentive is to set a price lower than either of the participant's two competitors. Each participant plays this game for 20 rounds with the same two other participants. The equilibrium of this game is for everyone to name a price of 0 and for everyone to earn 0 profit. On the other hand, if subjects can agree on a higher price and actually set that higher price, the profit-maximizing strategy is for every subject to set a price of 100 and for each subject to earn 33.3 each period.

Participants cannot communicate with each other for the first 10 rounds. However, they are able to text each other during the second set of 10 rounds (Fonseca and Normann, 2012). The frequency of communication varies according to the treatment group to which a participant is assigned. There are five treatment groups: texting each round, every other round, every three rounds, every four rounds, and every five rounds. Each conversation lasts for 30 seconds, and messages are sent through the Instant Messenger (IM) built into the game. The topic of the conversation can be anything and does not have to be related to the price. We advise participants to protect their own privacy and keep the discussion respectful. Participants also have the right to skip the conversation by clicking the "Next" button provided in the IM. The lowest price is disclosed to everyone at the end of each round, but the participant who has chosen it is not revealed.

This study was done on Amazon MTurk. The study involves a multi-player game that requires simultaneous interactions among participants. We posted recruiting materials on MTurker (MTurk workers) communities like turkerview.com, turkopticon.com, and reddit.com. The recruitment posts specified the exact date and time of an experiment. Anyone interested in this experiment and available at the announced time could submit an email address and MTurk ID via an attached link.

Each group of 3 subjects who arrived at our platform at a designated time and date were assigned to a group that would play together for 20 rounds. Each group was assigned to a treatment, denoted by the number of conversations allowed during the second 10 rounds of play: texting each round (N10), texting every two rounds (N5), texting every three rounds (N4), texting every four rounds (N3), texting every five rounds (N2), and the control groups (N0). There were ten groups for each treatment: 180 subjects total. All participants are asked about their age, gender, and education level at the beginning of the experiment. We prevented participants from joining the same study again by using options on Amazon M-Turk. Completing the experiment took 15-25 minutes. Subjects interacted for 20 rounds and each round lasted at most 40 seconds. All 20 rounds were played with the same group of 3 individuals.

Subjects were paid based on a total of 20 rounds of profit. 2000 points were worth $2, which was the maximum amount a single participant could earn as a monopolist if $p = 100$. Each participant earned his or her aggregated profit + a $2 completion fee at the end of the experiment. If one of the participants in a group left the experiment before the 20th round, the price of that player would be automatically set at 100, allowing the remaining 2 players to continue playing the game. The participant who failed to complete would be paid based on their profit up to that round but would not receive the $2 completion fee. There was no limitation on the amount of compensation available to the other two participants.

3.2 Amazon Mturk and oTree

This paper includes two crucial features. First, it is run on Amazon Mturk. Amazon Mturk is a revolutionary system that connects a large number of Mturkers to requesters. They are generally more diverse than student subjects but seem to respond to experimental stimuli in a manner consistent with the results of prior research (Cassese et al., 2013; Hoffman, et al., 2020).

Another important innovation is that the experiment was designed using oTree, an open-source, online software for implementing interactive online experiments (Chen et al., 2016). oTree uses Python, which is an open-source programming language and runs on any device that has a web browser. There are already many demo games and templates available online for researchers to use. We used Bertrand competition templates and modified them to run using oTree and Amazon Mturk.

4. Data

The experiments were conducted from July to November in 2019, except for holidays and weekends. To conform to the schedules that most MTurk subjects work, the experiments were open from 9 AM CT through 8 PM CT, with a new group of 6 subjects starting every 2 hours. We restricted participation to U.S. residents using MTurk's regional restriction system. 267 subjects started the experiment, but only 180 completed it. We allowed groups with only 1 or 2 participants to complete the experiment, but we do not include them in the data analysis. We continued running groups until we had data for 10 groups of 3 participants in each treatment.

Table 1 includes more detailed information on the number of subjects in each treatment. Although our samples are collected by their arrival time not by stratified random sampling, they are well distributed by their characteristics. The subsequent data analyses include only groups of 3 subjects who completed the experiment.

Table 2 shows the characteristics of participants who reported their personal information. Although not every participant provided his or her personal characteristics, we observe that they are randomly assigned to their tasks. Their education levels are (1) High school, (2) Some college, (3) Associate degree, (4) Bachelor's degree, (5) Master's degree, and (6) Doctoral degree. Their average age is 34-40 years old, education level is 2.8-3.6, and the male ratio is 41-61%.

5. Results

5.1 Simple Analyses

Table 3 shows the average payoff by treatment level. Each row represents a treatment effect. N0 is the control group. Compared to N0, all other groups earn higher payoffs on average, which means that communication among the three participants is associated with higher earnings. Moreover, payoffs to N10 participants are significantly higher than payoffs to participants in any other groups (p-value < 0.0001). The N10 group average payoff is nearly double the N0 group average payoff. The fact that the participants in the N10 were able to text before each of the second 10 rounds may be responsible for the difference.

Table 4 presents the average prices by treatment. There are five different treatments and a control group in the second 10 rounds. Bid means the average price bid by participants and Winning represents the average lowest price in each group. The Pre column shows the average price for the first ten rounds, and the Post column shows the average price for the second ten rounds. Although there is no significant difference between the pre and post winning prices in the N3 and N4 groups, overall we find that the average winning prices are higher in rounds 11-20 (post) than in rounds 1-10 (pre) The largest difference between pre-price and post-price is in the N10 group. Recall that N10 refers to the treatment in which participants can text before each pricing decision made in rounds 11-20.

Figure 1 presents the average winning price for all treatments and the control group.[1]The horizontal axis represents the round, and the vertical axis is the average winning price. There is a

[1] We also have the median winning price graphs for each group, and they show almost the same result.

declining trend for every group in the first ten rounds. What happens in rounds 11-20 depends on the frequency of texting. In the control group (N0), the price decline continues, converging toward the Nash equilibrium. In Group N2 (texting before rounds 11 and 15), prices rise at rounds 11 and 15, but then decline until the next text. In Group N3 (texting before rounds 11, 15, and 19) prices increase at those rounds, then fall after. In Group N4, (texting before rounds 11, 14, 17, and 20) prices rise for each of those rounds and then decrease. In Group N5 (texting at rounds 11, 13, 15, 17, and 19) price rises in each of those rounds and declines between. Only in N10 (texting before each round from 11-20) are subjects able to maintain an increase in prices, converging to a steady-state price of about 90 for the last 5 rounds. The difference between N10 and the other treatments demonstrates the power of texting before every price decision.

To investigate whether each group has the same distribution of winning prices, several nonparametric tests are used. **Table 5** shows the p-values of each test. Each row of **Table 5** reports the p-value of each test comparing the means or the distributions of winning prices. The first four rows present the results of the Kruskal-Wallis Equality of population rank test. The distribution of winning prices is not equal across treatments and N10 is significantly different from the combined distribution of all other groups. This result is statistically significant even when we do not restrict the results to only the texting rounds. We find the same results when we compare the distribution of winning prices using the Wilcoxon rank-sum test. In particular, the distribution of the winning prices in N10 is different from the distribution of winning prices in all other treatment and control groups. In the first ten rounds (pre-rounds) prices are not significantly different; there is no communication allowed in any group. In the post-rounds (11-20), the distributions are significantly different. The last part of **Table 5** includes the Jonckheere-Terpstra test which is a test for an ascending ordered alternative hypothesis. It confirms that N10 has a significantly higher distribution of winning prices than all other groups combined ($p<0.0001$ for rounds 11-20).

Table 6 shows the occurrence of cooperation during the experiments: groups that choose the same price more than two rounds in a row. Each row represents a group of 3 participants in a particular treatment. For example, the last row says that there is a group in treatment N10 who texts 10 times and agrees on a price of 99 for 5 rounds in a row and then 99 for another 4 rounds in a row. Note that with 3 participants, a price of 99 split 3 ways gives each participant a profit of 33. There are 24 examples of collusive behaviors: three in N0, five in N2, two in N3, three in N4, five in N5, and five in N10. The average length of rounds of collusion is 5, 3.6, 5, 2.6, 5.6 and 6.1 rounds, respectively. These results show that N10 is associated with longer collusive sequences of rounds and higher collusive prices.

5.2 Regression

Our equations are estimated in the form

$$p_{ij} = \beta_0 + \beta_1 nText * Post + \beta_2 nText + \beta_3 Post + \beta_4 Composition\ of\ Text + \beta_5 Individual\ Characteristics + \epsilon_{ij}$$

$$p_{ij} = \beta_0 + \beta_1 nText * Texting + \beta_2 nText + \beta_3 Texting + \beta_4 Composition\ of\ Text + \beta_5 Individual\ Characteristics + \epsilon_{ij}$$

where p_{ij} is the bid/winning price of individual *i* in round j. $nText$ is the level of treatment that is equal to the number of texting rounds that participants in the same group experience. *Post* is a dummy variable equal to 1 when $j > 10$. *Texting* is also a dummy variable which is equal to 1 if the number of a round is equal to their designated texting round.

Composition of Text variables are the proportion of statements regarding *Price* and *Denunciation* from the whole round, respectively. We omit *Others* to prevent multicollinearity. Individual characteristics include participant's sex, age, and education level. If cheap talk is effective, the more texting rounds allowed in the post-period, the higher the average prices.

Regressions supplement the above descriptive analyses. **Table 7** includes the main regression result with Age, Sex, and Education Dummies. We exclude from the regression participants who do not report their characteristics. In columns (1)-(2), the coefficients of *nText* (-2.188) and *Post* (-12.18) are both negative and significant. Although it is a random experiment, there is a negative relationship between nText and prices in the first ten rounds. Furthermore, prices are lower without texting in the second ten rounds compared to the first ten rounds. If we interact nText and *Post (nText#Post)* the coefficients for bids (+ 6.348) and winning prices (+ 6.581) are both positive and significant. It shows that the more texting opportunities a group is given, the higher their bids and the higher their winning prices.

Columns (3)-(4) use *Texting* instead of *Post*. The coefficients of $nText$ and *Texting* show the average differences between the control group and the treated groups. The coefficients of the interaction term (*nText#Texting*) for bids (+ 6.262) and winning prices (+ 7.039) are significantly positive, indicating significantly higher prices and winning bids in the treatment groups compared to the control group in the communication rounds.

The next row in Table 7 introduces a variable Price(%), which indicates the percentage of rounds a participant texts about price. On average, the participants who text more about price choose significantly higher prices, and in fact, help their groups achieve significantly higher winning prices. The coefficient for Price(%) is + 8.725 for bids and +10.15 for winning prices in columns (1)-(2), which shows a larger effect in columns (3)-(4). Interestingly, the coefficient for women is negative and significant for bids, but insignificant for winning prices. The coefficient for age is negative and significant for bids and insignificant for winning prices; and the coefficient for education is positive and significant for bids and insignificant for winning prices. Putting these coefficients together, on average older less educated women bid less and younger more educated men bid more, but those bids do not on average significantly affect winning prices.

5.3 End-game effect

At the end of each round participants are told how many rounds they have left. Knowing how many rounds remain raises the question of whether participants stop cooperation at the 20^{th} round (End-game effect). Among our 50 treated groups, we find five groups that include at least one participant who chooses a little lower price than the agreed price. There are two N2 groups and three N10 groups. Intuitively, 10% seems a relatively small number compared to the conventional wisdom that many people would deviate at the last round. However, participants who demonstrate an end-game effect achieve a higher average payoff (393.5 compared to others' 238), and the difference is statistically significant (t=12.13). Furthermore, their groups' average winning prices across all rounds are higher than others (52.45 compared to 34.96, t =9.8). That implies that groups with betrayers have worked well before the 20^{th} round. But participants who choose a lower price at the end get a higher individual payoff by breaking that long-term trust.

5.4 Texting Logs

Figure 2 shows examples of texts of groups who earn the lowest and the highest payoffs. The top box illustrates texts by the group that earns the lowest payoff. The lowest average treated group payoff is 49 points for one 3-person observation in treatment N4. An analysis of the texts shows that only player 1 participates in the conversation, and no one replies. No communication leads them to the lowest group payoff. They can do better if they all cooperate on choosing a price. The highest average group payoff is 483.66 for a 3-participant observation in treatment N4 (**Figure 2 box 2)**. This observation also includes the participant (P1), who earns the highest overall payoff (627). Every participant text every texting round to get a higher payoff at the end.

The highest average group payoff is almost ten times the lowest average group payoff. The additional profit each firm generates from participating in cheap talk is large. This result confirms that cheap talk before every pricing decision is a useful method to reach a collusive outcome. Although the communication cost is zero and the number of participants is small in our settings, we provide a fundamental background for explaining a cartel. The gap is so wide that firms in an industry are likely to establish a cartel if they can engage in cheap talk without restriction.

We further divide the comments into three groups: Price, Denouncement, and others. **Table 8** reports that more than 60% of the texting is about price. This shows the important finding that people naturally discuss price even when there are no guidelines or restrictions. The fact that only one of the treated groups does not discuss price at all shows that people want to discuss price. Furthermore, it is interesting that participants in our experiments try to follow or trust each other without any sanctions or coercion. **Figure 3** illustrates some denouncing statements from various groups. Overall, we observe a number of statements denouncing participants who have broken agreements. However, we do not observe participants who post such threatening conversations and then post lower prices.

6. Conclusion and Discussion

This paper presents the results of an experimental test of repeated Bertrand oligopolies with freestyle texting (cheap talk). This study compares different pricing behaviors between the first 10 rounds and the second 10 rounds, where participants can text in the second 10 rounds. We find that market prices are higher in texting rounds than in non-texting rounds. Furthermore, texting before choosing price every round results in close to monopolistic prices and significantly higher prices than even texting every other round. We also find that women, older participants, and less educated participants tend to choose lower prices, but these different pricing behaviors do not significantly affect market prices.

Even though participants can communicate anything in texts, they focus on price. We have only one treated group that does not discuss price. This result confirms a commonsense notion that increasing the number of communications in a market leads to a collusive outcome. Communication works as a mediator and proctor.

Cason (1995) points out that the modes of communication have kept pace with available technology, going from face-to-face exchanges to telephonic exchanges to computer exchanges. We use Amazon Mturk and an Instant Message system so that participants can represent the whole population and easily share their words. The experiment is an abstraction from reality, but it supports the argument that firms are able to fix prices through non-binding conversations. This experiment helps initiate an antitrust investigation. The fact that competitors hold a meeting is sufficient information to presume they are trying to collude. It is not necessary to analyze the conversations at their meeting.

Our future research question is to investigate the effect of face-to-face communications, such as Facetime, Skype, or Zoom, instead of texting. Face-to-face communication is more dynamic and fluid with verbal and facial expressions. Such communication also allows individuals to more accurately address important issues and concerns (Balliet, 2010). Moreover, there is experimental evidence that face-to-face discussion further increases cooperation (Hoffman and Spitzer, 1982, 1985, 1986; Bochet et al., 2006; Baranski and Kagel, 2015).

A limitation of this experiment is that we could not control the participants' previous experiences playing economic games. Although we limit them to play only once in our experiment, it would also be helpful to know whether some participants have more experience playing economic games than others. Such an experience might affect the results.

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Table 1 Number participants by treatment

	Number of participants in each group			Total
	1	2	3	
N0	0	6	30	36
N2	5	16	30	51
N3	2	14	30	46
N4	4	10	30	44
N5	0	6	30	36
N10	4	20	30	54

Note: We exclude groups of 1 and groups of 2 in our analysis.

Table 2 Characteristics of Participants

N0

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	25	39.64	13.87	19	69
Education	25	2.80	1.35	1	5
Male	25	0.56	0.51	0	1

N2

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	22	35.59	10.62	24	69
Education	22	3.55	1.26	1	6
Male	22	0.50	0.51	0	1

N3

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	22	33.77	9.78	22	58
Education	22	3.18	1.05	1	4
Male	22	0.59	0.50	0	1

N4

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	22	38.59	12.27	19	71
Education	22	3.05	1.25	1	5
Male	22	0.41	0.50	0	1

N5

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	23	36.78	10.77	23	64
Education	23	2.91	1.28	1	5
Male	23	0.57	0.59	0	2

N10

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	28	34.39	11.01	19	60
Education	28	3.43	1.29	1	6
Male	28	0.61	0.50	0	1

Note: This tables exclude participant who does not report their characteristics.

Table 3 Average payoff by number of texting rounds

	Mean	**SD**	**Min**	**Max**
N0	162.76	110.37	4	348
N2	249.95	128.91	48	520
N3	218.86	151.88	0	492
N4	216.05	138.55	26	627
N5	238.7	133.5	32	446
N10	309.21	123.99	55	506

Table 4 Average bid and winning price by the number of texting rounds: pre denotes first 10 rounds and post denotes rounds 11-20

N0

Variable	Pre	Post	Diff
Bid	43.3	37.02	-6.277**
	[1.70]	[1.87]	[2.530]
Winning	25.41	21.24	-4.170***
	[0.88]	[1.20]	[1.489]
N	300	300	600

N2

Variable	Pre	Post	Diff
Bid	42.44	47.08	4.637**
	[1.56]	[1.76]	[2.348]
Winning	29.12	40.15	11.030***
	[1.15]	[1.67]	[2.025]
N	300	300	600

N3

Variable	Pre	Post	Diff
Bid	49.25	51.04	1.797
	[1.63]	[1.97]	[2.551]
Winning	33.98	37.28	3.3
	[1.14]	[1.77]	[2.104]
N	300	300	600

N4

Variable	Pre	Post	Diff
Bid	51.28	44.92	-6.367**
	[1.86]	[1.68]	[2.503]
Winning	31.46	31.7	0.24
	[1.14]	[1.32]	[1.748]
N	300	300	600

N5

Variable	Pre	Post	Diff
Bid	42.77	53.88	11.110***
	[1.74]	[2.06]	[2.696]
Winning	27.31	43.44	16.130***
	[1.13]	[2.03]	[2.326]
N	300	300	600

N10

Variable	Pre	Post	Diff
Bid	26.35	83.51	57.160***
	[1.34]	[1.81]	[2.256]
Winning	15.6	77.07	61.470***
	[0.66]	[2.10]	[2.199]
N	300	300	600

Significance levels: * < 10% ** < 5% *** < 1%

Standard errors in parentheses

Table 5 Average winning price by the treatment group

	By	Period	P-value
Kruskal-Wallis Equality of population rank test	Number of texts	Whole	0.0001
	Number of texts	Only post	0.0001
	All others vs N10	Whole	0.0002
	All others vs N10	Only post	0.0001
Two-sample Wilcoxon rank-sum (Mann-Whitney) test	N2 vs N10	Whole	0.0315
	N3 vs N10	Whole	0.2374
	N4 vs N10	Whole	0.0728
	N5 vs N10	Whole	0.1010
	N0 vs N10	Whole	<0.0001
	N2 vs N10	Only post	<0.0001
	N3 vs N10	Only post	<0.0001
	N4 vs N10	Only post	<0.0001
	N5 vs N10	Only post	<0.0001
	N0 vs N10	Only post	<0.0001
Jonckheere-Terpstra Test for Ordered Alternatives	All others vs N10	Whole	0.0001
	All others vs N10	Only post	<0.0001

Table 6 Occurrence of Collusion

	Number of rounds	Price
N0	2	5
N0	9	5
N0	4	30
N2	5,5	50,100
N2	2,3	50,80
N2	2	10
N2	2	60
N2	6,4	45,100
N3	6	100
N3	4	95
N4	4	45
N4	2	100
N4	2	10
N5	10	50
N5	2	100
N5	4	100
N5	2	100
N5	10	100
N10	9	100
N10	9	100
N10	10	100
N10	5,9	50,100
N10	2,2	50,100
N10	5,4	99,99

Table 7 Regression

VARIABLES	(1) Bid	(2) Winning	(3) Bid	(4) Winning
nText	-2.188***	-1.718***	-2.127***	-1.775***
	(0.211)	(0.135)	(0.203)	(0.142)
Post	-12.18***	-11.21***		
	(1.709)	(1.341)		
Post # nText	6.348***	6.581***		
	(0.313)	(0.280)		
Texting			-9.326***	-13.54***
			(3.329)	(3.112)
Texting # nText			6.261***	7.039***
			(0.455)	(0.448)
Price (%)	8.725***	10.15***	12.86***	14.79***
	(1.535)	(1.291)	(1.512)	(1.257)
Denunciation (%)	-12.72*	-20.66***	-3.617	-10.43*
	(6.799)	(5.164)	(6.956)	(5.391)
Age	-0.190***	-0.0381	-0.200***	-0.0493
	(0.0506)	(0.0404)	(0.0499)	(0.0394)
Female	-3.861***	-0.239	-3.560***	0.1000
	(1.142)	(0.977)	(1.139)	(0.975)
Education	1.571***	0.262	1.492***	0.174
	(0.449)	(0.378)	(0.446)	(0.378)
Constant	46.03***	27.81***	43.82***	26.57***
	(2.644)	(1.997)	(2.545)	(1.901)
Observations	2,840	2,840	2,840	2,840
R-squared	0.205	0.297	0.215	0.306

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8 Composition of Texting by treatment

	Price	Denouncement	Others
N2	83%	1%	5%
N3	61%	1%	28%
N4	66%	2%	26%
N5	64%	9%	21%
N10	81%	3%	16%

Figure 1 Average winning price by the treatment group

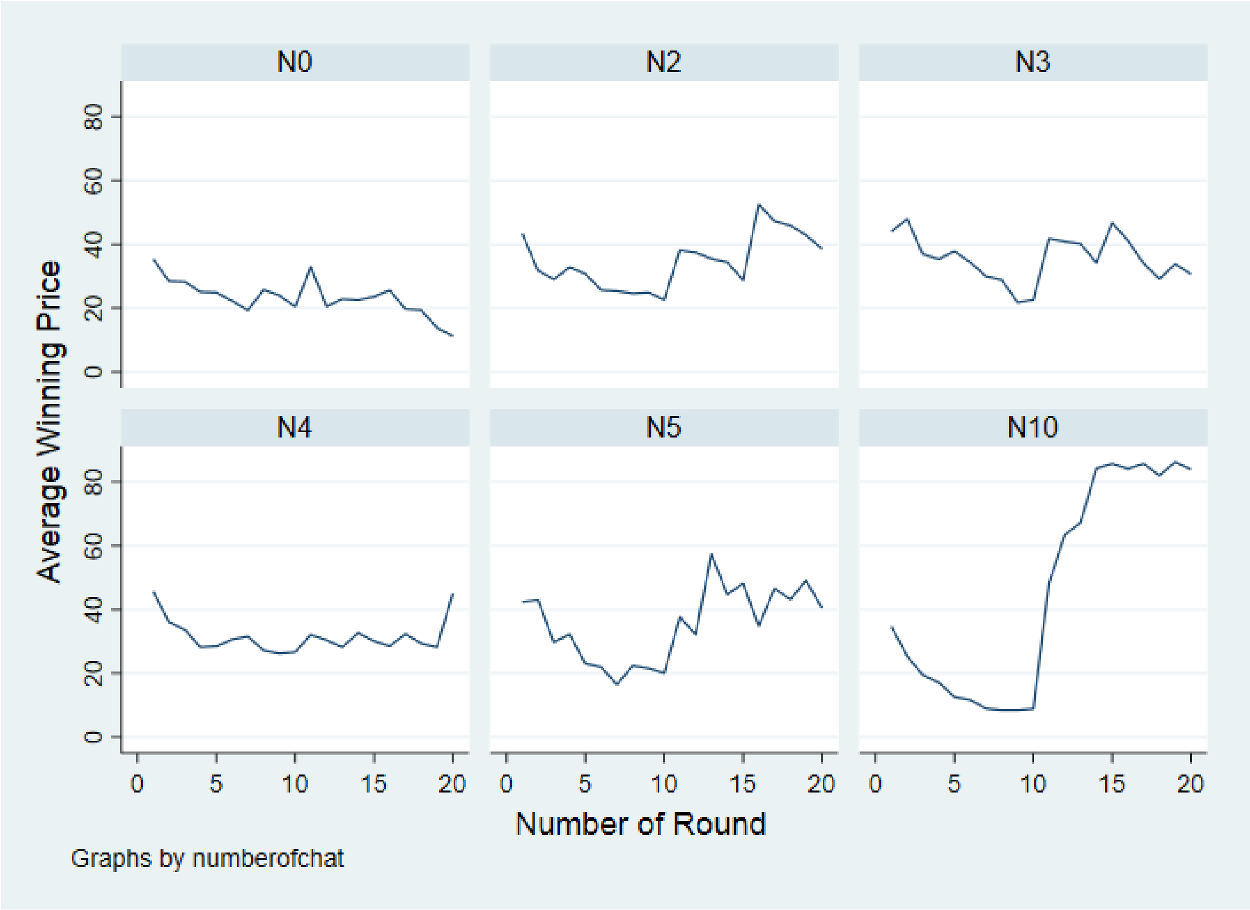

Figure 2 Texting log from the experiments

Box1

P1: Ok, so let's just all sell it for 95 and we all win? Deal?

P1: Stop being so selfish!!!!

P1: If we work together, we all make more bonus..

Box2

P3: Lets go 70!

P1: Okay

P2: ok

——

P3: Can we go up to 90?

P1: go to 80?

P3: why not go all in?

P1: okay

P2: ok

——

P3: So wait, what if all prices are equal? lets go 100

P1: ok

Figure 3 Denouncing text from several groups

well...someone's not in agreement clearly someone doesn't care what we discuss who was doing 10? i hate you Stop being so selfish!!!!

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