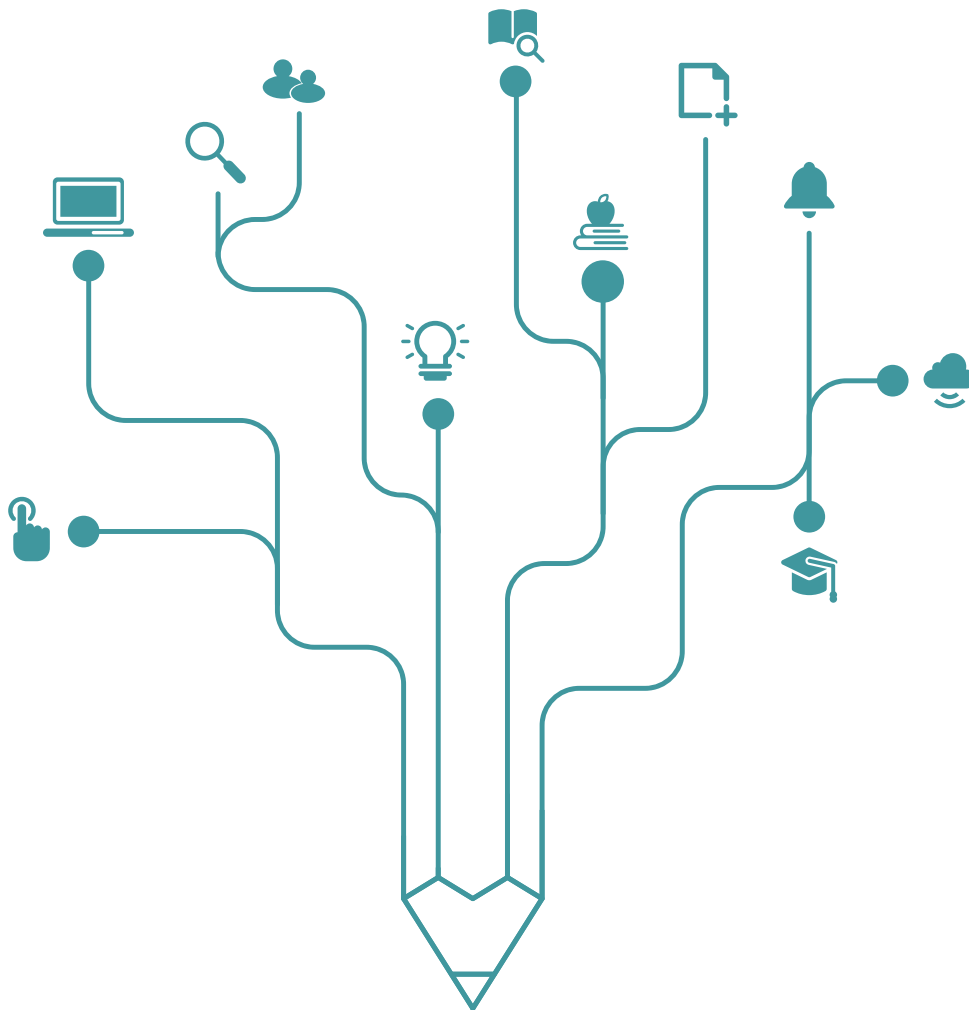


# Delegation and Strategic Collusion under Antitrust Policies: An Experiment

*Jeong Yeol Kim (KDI School of Public Policy and Management)*



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Jeong Yeol Kim\*

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## Abstract

When firm owners delegate decision-making to managers, such as corporate executives who operate firms directly, a firm's behavior can vary depending on how the owner determines the incentives of the managers. This study employs a lab experiment to investigate the impact of delegation on collusive behavior of firms in a situation where antitrust policies exist. The experiment highlights the following two key findings: (i) Firms form cartels strategically, alternating their collusive and competitive output to evade antitrust regulations, rather than consistently producing collusive output to maximize joint profits; and (ii) Delegation does not necessarily increase the overall number of cartels, but it may change how cartels are formed.

**Keywords:** Delegation, Collusion, Cartel, Antitrust

**JEL:** C9 K21 L2 L4 L44

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\* KDI School of Public Policy and Management, 263 Namsejong-ro, Sejong 30149, Republic of Korea (South Korea), jeongyeolkim@kdischool.ac.kr. I would like to express my sincere gratitude to the National Science Foundation (NSF) for providing funding through grant number SES-2149219, which made this research possible. Additionally, I am honored to announce that this paper has been recognized as the Winner by readers' choices of the 2023 Antitrust Writing Awards. An earlier version of this paper circulated under the title "Strategic Delegation and Collusion: An Experiment." Any errors or omissions are my own and no conflicts of interest are declared.

# 1 Introduction

In economics, collusion is often depicted in models as cooperation between firms, assuming that they act to maximize profits. However, in reality, firms have owners (e.g., shareholders) and managers (e.g., executives), whose incentives determine their behavior. In the practical operation of a firm, owners are primarily concerned with dividends, which are determined by profits. In contrast, managers' salaries are typically based on a firm's overall performance, including not only profits, but also revenue, sales, and other factors. The difference in incentives between owners and managers implies that the decision-making of the managers who actually run a firm may differ from the results predicted by economic models, which are based on the assumption of profit maximization. In other words, delegation to managers can influence a firm's performance and behavior. Therefore, this delegation may also impact cartel formation. Since participation in cartels is determined by those who directly manage the company, delegation can affect both explicit collusion through communication and implicit collusion (i.e., tacit behavior) that occurs without communication.

Another important consideration in collusion is antitrust laws. In economics, collusion is described as firms in a market conspiring to choose collusive prices or production levels to enjoy monopolistic profits. Previous papers that have modeled firms' cooperation in collusion have often discussed cartel formation without considering the impact of antitrust laws. However, antitrust policies affect the rate of cartel formation and the methods by which cartels are formed. For example, cartels can be established in a manner that evades existing regulations. By choosing prices or quantities that achieve stable excess profits, rather than monopolistic ones, cartels can form and maintain collusion while evading regulatory authorities' monitoring.

Building on the points discussed above, this paper examines how delegation under antitrust policies affects cartel formation, considering the presence or absence of communication. Specifically, the study investigates cartel formation in an environment where cartels are detected with a certain probability and fines are imposed, reflecting antitrust enforcement, to compare two scenarios: "No Delegation" and "Delegation." In the "No Delegation" scenario, which is commonly assumed in previous research, the owner and manager are the same individual, and their sole objective is to maximize profit. In contrast, the "Delegation" scenario assumes a separation between the owner and manager, with the manager's objective function determined by an incentive scheme set by the owner. This incentive scheme may focus solely on maximizing profit or incorporate other factors beyond profit, such as revenue.<sup>1</sup> In other words, delegation influences the manager's incentive scheme, which can affect the incentives for cartel formation. For this reason, the study considers the role of delegation.

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<sup>1</sup> According to [Bloomfield \(2021\)](#), weighted profit plus revenue-based payment schemes for CEOs and executives are more common in oligopolistic firms with a market share of 10% to 65%. The study provides empirical evidence that such schemes result in increased output and more aggressive market equilibria. These findings highlight the need to consider alternative assumptions to accurately predict firm behavior and market outcomes.

Additionally, the study follows prior research by incorporating environments where communication is either possible or impossible, to compare the formation of implicit and explicit cartels. This approach is motivated by the fact that delegation influences players' incentives for collusion, which in turn can lead to more complex variations in cartel formation patterns depending on whether communication is possible. Thus, to address these issues, the study employs a 2×2 experimental design, focusing on the two dimensions of delegation and communication.

This paper employs a Cournot-type duopoly delegation game based on [Fershtman \(1985\)](#), [Fershtman and Judd \(1987\)](#), [Sklivas \(1987\)](#), and [Vickers \(1985\)](#), collectively referred to as FJSV. Each owner, assumed to be a shareholder, focuses solely on their firm's profit and determines the incentive scheme for the firm's manager, choosing between profit-only or profit plus revenue. Each firm manager then decides on competitive (high) or collusive (low) output levels based on the incentive scheme provided by their firm owner. The experiment's antitrust policy is characterized by (1) a cartel detection rate and (2) fines. The application of antitrust policy is determined by the production choices made by the firm managers. In the delegation game, if managers' choices result in cartel formation (when all firms in a market opt for collusive output levels), there is a 15% chance that the cartel will be detected.<sup>2</sup> If detected, fines are imposed on the cartel firms, reducing the incentives for both owners and managers. Using this delegation game that incorporates antitrust policies, this research examines the impact of delegation on cartel formation rates and methods.

The study reveals two main findings. First, firms engaging in collusion act strategically to evade antitrust policies. Previous studies have described cartels as firms that simultaneously choose a collusive production level to maximize joint profit. However, this paper shows that colluding firms form "switching cartels," alternating between collusive and competitive production levels. Moreover, some detected cartels begin switching after being fined to evade antitrust monitoring. These results, consistent with [Harrington Jr \(2023\)](#), indicate a regulatory blind spot, in which a different form of cartel is possible.

Second, compared to the profit-maximization setting, the presence of delegation does not increase overall cartel formation rates but does influence the methods of cartel formation. The study results indicate that the formation rate of switching cartels is lower under delegation than in the setting without delegation. However, there is no significant difference in overall cartel formation rates between the two cases. Under delegation, managers' incentive schemes determined by owners can vary, leading to different incentives for cartel formation. In the experiment, managers tend to form cartels by selecting output levels that maximize joint profits rather than alternating between collusive and competitive output levels, as observed in switching cartels. This suggests that under delegation, cartels are formed in ways that facilitate easier monitoring of members' adherence to collusive agreements.

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<sup>2</sup> The 15% cartel detection rate is based on empirical estimates from several studies: [Bryant and Eckard \(1991\)](#) estimated 13-17% using U.S. data, [Combe et al. \(2008\)](#) estimated 12.9-13.3% using EU data, and [Ormosi \(2014\)](#) showed a 10-20% rate using EU data. This rate has been adopted in experimental studies by [Hinloopen and Soetevent \(2008b\)](#), [Clemens and Rau \(2019\)](#), [Kim and Noussair \(2023\)](#), and [Bodnar et al. \(2023\)](#).

The paper is organized as follows. Section 2 discusses the prior literature on how delegation and communication affect collusion among firms. Section 3 introduces the experimental design and the treatments. Section 4 presents the main hypotheses derived from theory and previous research. Section 5 examines market outcomes (profit and output), how cartels are formed and how many are formed, and how antitrust regulation affects cartel formation for each treatment. Section 6 concludes.

## 2 Literature review

Previous studies have investigated the use of delegation models and have questioned the precision of the profit maximization assumption in describing firm behavior. FJSV investigate firms' non-profit-maximizing behavior through the use of a Cournot duopoly two-stage game, referred to as "strategic delegation." In the first stage, each firm's owner sets up an incentive scheme for its managers, with the scheme determined by the weight given to profit and revenue in a range from 0 to 1. For instance, if an owner assigns equal weight to profit and revenue, the managers' incentives would be based on a combination of half profit and half revenue. In the second stage, each firm's managers decide on the production levels for their firms. The study finds that if owners choose a sales-focused incentive scheme for their managers, then managers will act more aggressively to maximize their incentives compared to a profit-focused incentive scheme, resulting in firms' non-profit-maximizing behavior. This highlights that strategic delegation can contribute to non-profit-maximizing behavior by firms in a market.

Many papers have extended FJSV's model by including more specific real-world components related to the managers' incentives. [Jansen et al. \(2007\)](#) and [Ritz \(2008\)](#) add "market share" to profit and sales in FJSV's delegation game. In their model, there are three contracts from which an owner can choose between as an incentive scheme for the managers. Two of the three contracts are the same as the ones adopted by FJSV and address whether a manager's salary is determined by profit alone or profit and weighted sales; the new contract stipulates that a manager's salary is proportional to the profit and weighted market share. The papers show that when an owner selects the market share-oriented contract, the managers produce more output than when another firm chooses a profit-alone or sales-oriented contract. This illustrates that firms may choose a higher output than that obtained under the profit maximization assumption, a finding that aligns with FJSV's results. The authors also verify that the result of a Bertrand-type delegation model is consistent with the result of their Cournot-type model.

Similarly, [Miller and Pazgal \(2002\)](#) and [Jansen et al. \(2009\)](#) incorporate relative profit (compared with other firms) in the managerial incentive contract in their delegation models. They find that delegation may result in higher output and lower prices compared to the predictions of the profit maximization assumption. The results of these studies are consistent with those of FJSV. [Habiger and Kopel \(2020\)](#) and [Fang and Zhao \(2021\)](#) further extend the delegation models, incorporating product differentiation with asymmetric costs. In their Cournot duopoly models, they find that managers produce output more aggressively when their firms are more cost-efficient or when the products in the

market are less differentiated. These findings suggest that when delegation and other factors are taken into account, market outcomes may differ from those predicted by the profit maximization assumption.

In addition to these studies on delegation models, some papers have shed light on firms' tendency not to maximize profits. [Dutta and Radner \(1999\)](#) presents a theoretical model in which firms typically fall short of maximizing profits in both the short and long term. In the model, firms are motivated to attract investment funds and attain positive profits in order to survive in a competitive market. The authors find that entrepreneurs are more likely to increase their output aggressively in order to avoid bankruptcy and attain positive profits than would be expected under the profit maximization assumption. [Oprea \(2014\)](#) takes into account that firms are concerned with their survival in the market and examines whether firms aim to maximize profits. He conducts an experiment with two hypothetical environments where the survival rates of firms are either high or low. The author shows that firms attempt to maximize profits if they have a high survival rate, but not otherwise. This finding based on firm survival rates implies that the assumption of profit maximization may not be appropriate for analyzing firm behavior. [Güth et al. \(2015\)](#) designs a delegation game that includes the costs and compensation for workers' efforts. In the model, workers' compensation is based on revenue. Workers can choose their levels of effort and production, considering their individual performance. The research finds that the effectiveness of delegating decision making to workers depends on the level of competition in the market (interfirm competition) and the number of workers within a firm (intrafirm competition). This suggests that firms may not achieve profit maximization due to competition with other firms or competition between managers within a firm.

Several experimental studies have investigated the concept of delegation. [Fershtman and Gneezy \(2001\)](#) examine the impact of delegation on agents' behavior through an ultimatum game that involves a proposer and a responder. The proposer is tasked with dividing 100 points between themselves and the responder. In the game, either the proposer or the responder can delegate authority to an agent, and the contract determining the agent's payoff may or may not be visible. The results of the experiment show that delegation from the proposer (responder) leads to an increase in the proposer's (responder's) payoffs when the contracts for agents are visible. However, if the contracts are not visible, delegation may not serve as an effective commitment device for either the proposer or the responder. Although [Fershtman and Gneezy's](#) framework differs from the FJSV model, they demonstrate that delegation and contracts for agents can influence the outcome of a game.

[Huck et al. \(2004\)](#) conduct an experiment to study the impact of delegation on firm behavior. Their experiment utilizes a two-stage Cournot duopoly game based on the FJSV model, with each firm consisting of one owner and one manager. The authors establish two contracts for managers' salaries: Contract A, where a manager's salary is solely proportional to profit, and Contract B, where it is proportional to profit and a sales bonus. During stage 1, owners simultaneously choose their contracts, and during stage 2, each manager decides the firm's production quantity. The theoretical model expects both firms to choose Contract B, resulting in managers producing output higher than the profit-maximizing output as a subgame perfect equilibrium. However, the experimental results indicate that

both firms frequently choose Contract A, which suggests that the prediction does not hold in practice.

An experiment by [Du et al. \(2013\)](#) extends the FJSV model to a “mixed duopoly” market featuring a profit-maximizing private firm and a welfare-maximizing public firm, where managers’ incentives schemes are a combination of profit and sales, as in FJSV’s model. The authors find that the public firm, which prioritizes welfare, produces more output than the private firm, which prioritizes profit. The results of the experiment indicate that delegation leads to an increase in market output, which aligns with the results of previous theoretical and experimental studies. In another experiment, [Barreda-Tarrazona et al. \(2016\)](#) use a delegation model with two managerial incentive contracts: one based on profit-revenue and the other based on relative firm performance, similar to the theoretical model of [Jansen et al. \(2009\)](#). The experiment allows owners and managers to choose parameters within a continuous field, with owners weighing revenue or relative performance and managers determining output. The authors find that delegation results in owners choosing non-profit-maximizing contracts and managers producing higher market output than predicted by the profit maximization assumption, a finding consistent with the results of this study.

Some experiments have investigated how the presence and richness of communication affects collusion. [Fonseca and Normann \(2012\)](#) compare firm behavior with and without communication. The authors design four Bertrand oligopoly markets with varying numbers of firms (2, 4, 6, and 8) and observe the firms’ price decisions. The prices selected by the subjects determine the firms’ profits and payoffs. The authors find that communication increases the rate of cartel formation, with the median-sized market (four firms) having the highest number of cartels among the four markets. The experiment of [Cooper and Kühn \(2014\)](#) divides communication levels into no communication, limited messages, and free chat, showing that merely delivering the intention to collude may not be enough to sustain cartels, but that rich communication increases cartel stability. [Bigoni et al. \(2019\)](#) investigate the impact of interaction frequency on the collusion of firms in a duopoly experiment. The experiment involves two firms choosing quantities in fixed periods, with random shocks affecting their profits. The fixed period length differs across three treatments, from 1 to 3. In the game, a firm can see the prices determined by the chosen quantities but does not know about the random shocks or the other firm’s choice. The experiment supports the view that communication increases cartel formation and highlights that communication is essential to forming a cartel under imperfect monitoring.

Furthermore, there are experiments that examine how the structure of communication affects collusion. [Harrington Jr et al. \(2016\)](#) investigate how different modes of communication among firms affect collusion. The experiment categorizes three communication modes: no communication (NC), price announcements where firms freely announce future prices (AN), and free-form chatting (CH). Additionally, the number of firms varies from two to four, and both symmetric and asymmetric cost structures are considered. The results indicate that free-form communication is the most effective for successful collusion, regardless of the cost structure and the number of firms in the market. In contrast, price announcements are only effective in markets with two firms and are ineffective in other scenarios. This suggests that direct communication makes collusion easier to achieve.

[Flannery and Wang \(2023\)](#)'s experiment compares the effectiveness of partial communication and full communication in facilitating collusion among firms. Their experiment involves groups of three players subjected to four treatments: no communication (N0), partial communication where only two of the three can communicate with each other (N1), communication where a leader can talk with the other two but the two cannot talk with each other (N2), and full communication where all participants can communicate with each other (N3). This setup allows for an examination of how the network structure and the degree of communication freedom impact collusion. The results indicate that collusion rates are highest when all participants can communicate equally. [Grandjean et al. \(2017\)](#) study the impact of public and private communication on coordination. Their experiment includes four communication structures: no communication (NoCom), public communication where all players can only send public messages (Public), private communication where all players can only send private messages (Private), and a scenario in which both are allowed (Both). Participants face a coalition prisoner's dilemma with two Nash equilibria: a Pareto superior equilibrium and a Pareto inferior equilibrium. The results show that the Public structure led to more frequent attainment of the Pareto superior equilibrium, indicating that public communication fosters higher levels of cooperation and trust. In contrast, the introduction of private communication increased deviations from cooperation, leading to more frequent attainment of the Pareto inferior equilibrium.

[Andersson and Wengström \(2007\)](#) investigate the impact of costly communication on market prices and cartel stability. Their experiment imposes costs in the form of an antitrust policy and categorizes treatments into Zero-, Low-, and High-cost communication based on the size of the cost. The results show that higher communication costs lead to higher market prices. Additionally, higher costs reduce the number of exchanged messages among subjects, but increases their cartel stability. This indicates that restricting communication through antitrust policy may facilitate collusion. [Bigoni et al. \(2015\)](#) employs a lab experiment to examine the effect of antitrust law on cartel formation. Participants engage in communication, price setting, and leniency application decisions. There are three treatments: L-Faire (no regulation), Fine (cartel detection and fines without leniency), and Leniency (first whistleblower receives a fine exemption). Each treatment varies in fine size (200, 1000) and detection probability (2%, 10%). The results indicate that the presence of a leniency policy and higher fines enhance the deterrence effect on cartel formation. However, when fines are low, a leniency policy may increase cartel stability.

[Clemens and Rau \(2019\)](#) investigate the impact of antitrust law in the presence of a ringleader within a cartel. The experiment examines competition and collusion among four firms selling homogeneous products in a Cournot market. The treatments are AA (antitrust authority enforcement), LEN (leniency policy applicable to all participants), and RD2 and RD4 (restricting leniency applications for ringleaders). The results show that restricting ringleaders' leniency applications effectively deters cartel formation, whereas leniency policies without such restrictions do not. [Kim and Noussair \(2023\)](#) examine the effects of different antitrust laws on cartel formation and detection. Considering different fine sizes (High, Low) and the partial exemption for subsequent whistleblowers,

the treatments are No-len (no leniency), High1 and Low1 (complete exemption for the first whistleblower), and High2 and Low2 (50% exemption for a second whistleblower). The experiment results show that while leniency policies do not deter cartel formation, they increase cartel detection rates. Moreover, partial exemptions for subsequent whistleblowers fail to significantly deter cartel formation.

In brief, previous studies on delegation demonstrate that the interests of owners who focus solely on profit are not always consistent with those of managers who are concerned with their salaries. Previous research shows that managers tend to produce more output to maximize their salaries, which results in firms not maximizing their profits. In addition, previous studies indicate that communication can increase the formation and stability of cartels. However, the impact of delegation on cartel formation under antitrust policies remains unclear. This paper aims to shed light on this question.

### 3 Experimental design

#### 3.1 Basic setup

This study employs a finitely repeated delegation game in a Cournot duopoly setup, following the FJSV model. The game features a finite number of rounds, each consisting of two stages. The market comprises two firms, labeled 1 and 2, each with one owner and one manager. The study assumes a linear demand and a constant marginal cost to describe approximately 20% of the actual cartel overcharge observed in the real world.<sup>3</sup> The inverse demand function  $p$  is

$$p(q_1, q_2) = 140 - q_1 - q_2 \quad (1)$$

where  $q_i$  is firm  $i$ 's output,  $i = 1, 2$ . The marginal cost in this study is equal to 40. The profit and revenue of each firm are represented as  $\pi_i$  and  $R_i$ , respectively, where  $i$  refers to the firm number, 1 or 2. The owners of each firm are assumed to be concerned with their respective firm's profit, as detailed in Appendix A.1. The objective function for the payoff of each firm's manager is defined as  $U_i$ ,  $i = 1, 2$ .

$$U_i^P = \pi_i = (100 - q_1 - q_2)q_i \quad (2)$$

$$U_i^R = 0.5\pi_i + 0.5R_i = 0.5(140 - q_1 - q_2)q_i + 0.5(100 - q_1 - q_2)q_i \quad (3)$$

In stage 1, the *Delegation* stage, each firm owner decides on delegation by selecting between contracts **P** and **R**. This determines the objective function for a manager's payoff. When contract **P** is selected,

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<sup>3</sup> Connor and Lande (2008) estimate the median cartel overcharge to be approximately 20% and Boyer and Kotchoni (2015) estimate it to be around 16%. Based on these estimates, Clemens and Rau (2019) implement a cartel overcharge of about 17% in their experiment. Following these studies, this research sets the demand function and marginal cost to achieve a realistic cartel overcharge of approximately 20%.

a manager's payoff is proportional to the firm's profit alone, as indicated  $U_i^P$  by Equation (2). On the other hand, contract **R** represents a situation where the manager's payoff is proportional to half the profit and half the revenue, as described in Equation (3) with  $U_i^R$ . Based on the two firm owners' selections, there are four possible combinations for managers of firms 1 and 2; (P, P), (P, R), (R, P), and (R, R). The symmetric cases of (P, P) and (R, R) have managers with the same objective functions for their payoffs, while the asymmetric cases of (P, R) and (R, P) result in different objective functions for the managers. At the end of Stage 1, the contracts chosen by the owners become common knowledge to all players in the game.<sup>4</sup>

In stage 2, the *Collusion* stage, each firm manager simultaneously chooses between **L** (low output) and **H** (high output). The payoff of each owner corresponds to their firm's profit, whereas the payoffs of the managers depend on both the contracts selected by the owners and the output selected by the managers. The outputs available for selection by the managers in stage 2 vary based on the contracts chosen by the owners in stage 1, and the manager's choice of L or H determines the amount of output produced.<sup>5</sup>

For the symmetric cases, where (P, P) or (R, R) has been selected, this study considers three types of output to calculate owners' and managers' payoffs: (i) (L, L) is the conventional way of forming a cartel, in which the joint profit of the two firms is maximized. In this case, the output maximizing joint-objective functions of the two managers are used. (ii) (H, H) represents competition between the managers, where both managers maximize their individual objectives. Thus, in the (H, H) case, the Cournot competition output is used. Finally, (iii) (L, H) and (H, L) depict scenarios where a manager deviates from the cartel. In these cases, the defection output is utilized to describe a manager's incentive to break from the collusion. For example, in the case (P, P), both managers have the same objective function:

$U_1^P = \pi_1 = (100 - q_1 - q_2)q_1$  and  $U_2^P = \pi_2 = (100 - q_1 - q_2)q_2$ . Using these two equations, the output  $(q_1, q_2)$  for (L, L) is (25, 25), and the output for (H, H) is (33, 33). If firm 1 deviates from the cartel while firm 2 does not, the output for (H, L) is (38, 25). In the experiment, symmetric cases have three different outputs: collusion, competition, and one firm's defection.

For the asymmetric cases where either (P, R) or (R, P) is chosen, it can be challenging to describe collusion, competition, and one firm's defection. For instance, if firm 1's owner selects P and firm 2's owner selects R in stage 1, the managers' objective functions are  $U_1 = \pi_1 = (100 - q_1 - q_2)q_1$  and

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<sup>4</sup> This experiment assumes, based on the requirements of U.S. federal securities law, that owners' contracts for management incentives are publicly disclosed. The law mandates the disclosure of compensation paid to CEOs and high-ranking managers. Specifically, the Compensation Discussion and Analysis (CD&A) section provides comprehensive information on executive compensation programs.

<sup>5</sup> This study assumes that the owners' profit is independent of the managers' payoffs, consistent with previous research (FJSV; Huck et al. (2004)). If the managers' payoffs were subtracted from the owners' profit, then the prediction would depend on the relative gap between the managers' payoffs and the profit, influenced by the parameters of the demand function and marginal cost. However, this experiment focuses on the impact of delegation on firm behavior and the market, not the effect of this relative gap. Thus, this assumption simplifies the analysis of firm behavior and the market under delegation. Further reasoning for this assumption is explained in Appendix A.1.

$U_2 = 0.5\pi_2 + 0.5R_2 = (100 - q_1 - q_2)q_2$  In this scenario, the Cournot competition output is (27, 47), but there can be multiple possible collusive outputs for (L, L) in asymmetric cases, as noted by Ivaldi et al. (2003).<sup>6</sup> To address this, this study adopts the “alternative monopoly output” for (L, L) in the asymmetric cases. The alternative monopoly output of each manager is defined as half of their monopoly output. For example, firm 1’s monopoly output is 50, and firm 2’s is 60. Thus, the alternating monopoly output for firms 1 and 2 is (25, 30).<sup>7</sup>

		$q_2$					
		P			R		
$q_1$	P	L	H	L	H	L	H
		L	(25, 25)	(25, 38)	L	(25, 30)	<b>(27, 47)</b>
	H	(38, 25)	<b>(33, 33)</b>	H	(35, 30)	(35, 47)	
	R	L	H	L	H		
L	(30, 25)	(30, 35)	L	(30, 30)	(30, 45)		
H	<b>(47, 27)</b>	(47, 35)	H	(45, 30)	<b>(40, 40)</b>		

\* Bold numbers indicate a Nash equilibrium for each subgame in the cases (P, P), (R, R), (P, R), and (R, P).

Table 1: Outputs for the two-stage strategic delegation game

In asymmetric cases, there is an issue to consider when determining the position of competition and defection outputs. For example, when (P, R) is chosen, the collusive output for (L, L) is (25, 30). If firm 1 deviates from the collusion, then the defection output is (35, 30). If firm 2 deviates, then the defection output should be (25, 47.5). When the firms compete with each other, the competitive output is (27, 47). The little difference between (25, 47.5) and (27, 47) makes it difficult to distinguish competition from deviation by firm 2. To address this issue, the competitive output (27, 47) is used for firm 2’s defection output and (35, 47) is set for (H, H). This arrangement accommodates collusion, competition, and one firm’s defection output.<sup>8</sup> The possible outputs for the two-stage game are indicated in Table 1.

<sup>6</sup> Ivaldi et al. (2003) highlights that, unlike in symmetric situations where a joint-profit-maximizing output can be found, it is not possible to identify a unique collusive output in asymmetric situations. For instance, in the example of (R, R), the managers of firms 1 and 2 could theoretically maximize their joint payoff by producing outputs of (0, 60) respectively, instead of (30, 30). However, it is unrealistic for one firm to produce nothing in a collusive arrangement, and this scenario does not explain firm 2’s incentive to deviate from the cartel. To address this issue, Fischer and Normann (2019) conduct an experiment to determine which of the several possible collusive outputs in an asymmetric duopoly market is closest to the actual collusive output.

<sup>7</sup> In the research of Fischer and Normann (2019), the alternative monopoly output, defined as the convex combination of two firms’ monopoly output:  $wU_i + (1 - w)U_j$ , where  $w \in [0,1]$ , is one of the closest outputs to the collusive output in an asymmetric duopoly market. They find that the alternative monopoly output with a weight of  $w = 0.5$  is one of the closest outputs to the collusive output. Therefore, this study adopts the alternative monopoly output with  $w = 0.5$ , which is half of each manager’s monopoly output, as the collusive output in asymmetric cases.

<sup>8</sup> The experimental setting is designed to illustrate that competition between the two firms is close to one firm’s deviation from collusion in asymmetric cases. The setup takes into account that a manager with R has a greater incentive to deviate from the cartel than a manager with P. This structure is similar to the setting used by Huck et al. (2004). However, they only use collusive and competitive outputs and do not include defection outputs. In asymmetric cases in their setting, the benefits of collusion for the firm with R (i.e., the difference in payoffs between competition and deviation) would be under-valued. To address this issue, this study uses defection outputs from collusion.

Treatment	Players	Stage		
		Delegation	Communication	Collusion
PN	2 players	-	-	✓
PC	2 players	-	✓	✓
DN	2 owners + 2 managers	✓	-	✓
DC	2 owners + 2 managers	✓	✓	✓

\*In the PN and PC treatments, there is no delegation. This means owners = managers. Therefore, those treatments are regarded to be administered by two players, who are owners as well as managers. In the DN and DC treatments, owners and managers are separate. Thus, each owner chooses their manager's incentive scheme in the *Delegation* stage. Then, each firm manager in those treatments chooses low or high output. The *Communication* stage occurs before the *Collusion* stage in PC and DC treatments.

Table 2: The stages for each treatment

This experiment takes into account the possibility of cartel fines, which would be imposed by an antitrust authority in the event that a cartel is detected. If the two managers choose (L, L) at stage 2, there is a 15% chance that the cartel will be detected and fined. The fine imposed on cartel firms is set at 10% of revenue, according to previous research (Apesteguia et al. (2007); Hinloopen and Soetevent (2008a); Bigoni et al. (2012)). If the cartel is detected, the profit of the cartel firms will decrease, resulting in a decrease in the owners' payoffs. When a cartel is regulated by antitrust law, not only are the owners of the cartel fined, but the managers may also lose their compensation and may even be punished. To account for this, in the experiment, just as the owners' profits are affected by the penalties imposed on the cartel firms, the managers' payoffs are reduced. The size of the fine imposed on each manager is equivalent to approximately 20% of the manager's payoff, set in conjunction with a 10% proportion of the firm's revenue.

### 3.2 Treatments

This study compares two scenarios: (i) delegation and (ii) no delegation (i.e., profit maximization), both with and without communication. There are four treatments in total: profit maximization with no communication (**PN**), profit maximization with communication (**PC**), delegation with no communication (**DN**), and delegation with communication (**DC**).

In PN and PC treatments, players are owners as well as managers. The players choose the outputs themselves to maximize profit with no delegation. Thus, there are only two players in each group in PN and PC treatments. The PN treatment consists of a single stage, *Collusion*, while the PC treatment has two stages, *Communication* and *Collusion*. In the PC treatment, players communicate with each other for one minute before choosing L or H in the *Collusion* stage. The players can view their payoff tables during communication. If both players choose L, there is a 15% chance that the cartel will be detected and fined, with the size of the fine for each cartel firm being 10% of its revenue.<sup>9</sup> For example,

<sup>9</sup> In this experiment, even in cases where there is no communication (the PN and DN treatments), a 15% probability of a fine for collusion is imposed when selecting (L, L). Punishing cartels based solely on circumstantial evidence without direct

if players choose (L, L), the output for collusion is (25, 25), and using the inverse demand function  $p(q_1, q_2) = 140 - q_1 - q_2$  and marginal cost  $c = 40$ , the price of the cartel is 90 and its profit for each firm is 1250. The revenue of each firm is 2250, so the cartel fine is 225. This results in a cartel profit of 1025 in the 15% probability scenario that the cartel is detected and fined or 1250 profit with no detection. At the end of each round, payoffs, including fines, are announced. Table 3 presents the payoff tables for players in PN and PC treatments.

		Player 2's payoff	
		L	H
Player 1's payoff	L	1250, 1250 (with 85%) or 1025, 1025 (with 15%)	(925, 1406)
	H	(1406, 925)	<b>(1111, 1111)</b>

Table 3: Players' payoff table for PN and PC treatments

		The payoff of firm 2's owner					
		P		R			
		L	H	L	H		
The payoff of firm 1's owner	P	L	1250, 1250 (85%) or 1025, 1025 (15%)	(925, 1406)	L	1125, 1350 (85%) or 912, 1095 (15%)	<b>(702, 1222)</b>
		H	(1406, 925)	<b>(1111, 1111)</b>	H	(1225, 1050)	(630, 846)
	R	L	1350, 1125 (85%) or 1095, 912 (15%)	(1050, 1225)	L	1200, 1200 (85%) or 960, 960 (15%)	(750, 1125)
		H	<b>(1222, 702)</b>	(846, 630)	H	(1125, 750)	<b>(800, 800)</b>

Table 4: Owners' payoff table for DN and DC treatments

The DN and DC treatments include a *Delegation* stage, where each group consists of two owners and two managers representing two respective firms in a market. The DC treatment involves three stages: *Delegation*, *Communication*, and *Collusion*. In the *Delegation* stage, each owner selects P or R and can view not only their own payoff tables, but also their managers' payoff tables for all four possible outcomes. The owners' decisions determine their managers' payoff tables. In the

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proof of communication is challenging, but nevertheless, countries belonging to the Organization for Economic Co-operation and Development (OECD), where competition laws exist, impose penalties based on circumstantial evidence (OECD, 2007). In this paper, I design the experiment in such a way that in the event of "detection," based on such circumstantial evidence, a 15% probability results in a fine of 10% of the revenue of colluding firms. This design is valuable for comparing how the formation of cartels is influenced by the presence or absence of communication.

		$U_2$	
		L	H
$U_1$	L	125, 125 (85%) or 102, 102 (15%)	(93, 141)
	H	(141, 93)	<b>(111, 111)</b>

(a) (P, P)

		$U_2$	
		L	H
$U_1$	L	138, 124 (85%) or 112, 101 (15%)	<b>(95, 145)</b>
	H	(148, 94)	(111, 111)

(b) (P, R)

		$U_2$	
		L	H
$U_1$	L	124, 138 (85%) or 101, 112 (15%)	(94, 148)
	H	<b>(145, 95)</b>	(107, 88)

(c) (R, P)

		$U_2$	
		L	H
$U_1$	L	128, 128 (85%) or 102, 102 (15%)	(83, 150)
	H	(150, 83)	<b>(108, 108)</b>

(d) (R, R)

Table 5: The four possible payoff tables for managers in the DN and DC treatments

*Communication* stage, managers chat with each other for one minute while viewing the payoff tables determined by the firm owners' decisions. After the chat, the managers simultaneously choose L or H in the *Collusion* stage. Based on the managers' decisions, the payoffs for both owners and managers, including fines, are announced to everyone, and the round is completed. The DN treatment is similar to the DC treatment, but without the *Communication* stage. Table 4 presents the owners' payoff tables, while Table 5 displays the managers' four possible payoff tables, which vary depending on the owners' decisions.

### 3.3 The sessions

Each subject is assigned to a group before the start of a session. For the DN and DC treatments, each group consists of four subjects. At the beginning of the session, each subject is assigned a firm designation (1 or 2) and a role (owner or manager). In the PN and PC treatments, each group consists of two subjects who are assigned to either firm 1 or 2. The session consists of sixteen rounds.<sup>10</sup> After the

<sup>10</sup> See Normann and Wallace (2012) and Embrey et al. (2018). In the study by Normann and Wallace (2012), it was shown that the length of a game in a finitely repeated setting can increase the cooperation of firms. The results of Normann and Wallace's experiment revealed that the cooperation rate for a 10-round game was 41%, while the cooperation rate for a 22-round game was 44%, providing support for the sixteen-round setting used in this study. Furthermore, in infinite repeated settings in Normann and Wallace's study, higher cooperation rates were observed, but the conclusion that the length of a game increases firms' cooperation remained unchanged. Additionally, according to the results of Embrey et al. (2018), when the length of the round is sufficient, subjects can cooperate until reaching a threshold round in a finitely repeated game that has only one non-cooperative equilibrium. This result suggests that finitely repeated games can be used to describe the rates of cartel formation among firms.

completion of the sixteen rounds, the cumulative payoffs from each round are provided to the subjects.<sup>11</sup> The experiment involved 120 participants, who were recruited from the Economic Science Laboratory at the University of Arizona in Tucson, Arizona, USA, and divided into ten groups for each treatment.

The experiment was programmed using oTree (Chen et al. (2016)). The average run time for a session was 35 to 45 minutes, depending on the treatments' different stages. An experimental currency, Point, was used to denominate payoffs. Owners received one dollar for every 2,000 points, while managers received one dollar for every 200 points.<sup>12</sup> The subjects received 18.1 dollars on average, including a show-up fee of 5 dollars.

## 4 Hypotheses

Based on the experimental design and the equilibrium of each treatment, this paper develops four hypotheses. The first two hypotheses compare the rate of cartel formation under delegation to that under profit maximization. These hypotheses are based on the subgame perfect equilibria of the respective games. The game is finitely repeated, and as discussed, the stage game has a unique subgame perfect equilibrium. Therefore, the only subgame perfect equilibrium of the repeated game is for all players to play the single-period subgame perfect equilibrium in each period.

In the PN and PC treatments, the two players, who are owners as well as managers of firms, simultaneously choose between actions L and H, as shown in Table 3. Each player has a strictly dominant strategy to choose H in the stage game. Hence, the unique Nash equilibrium of the stage game is for both players to choose H, resulting in the unique subgame perfect equilibrium of the finitely repeated game.<sup>13</sup> In this equilibrium, players choose H in each period for each possible previous history of play, resulting in an equilibrium of (H, H) and a payoff of 1,111 to each player in each period. The cheap talk communication in the PC treatment does not affect the set of equilibrium outcomes.

In the DN and DC treatments, each period consists of two stages. During the first stage, the owners determine the incentive structures for their own managers. In the second stage, the managers choose their outputs. The resulting payoffs for the owners can be found in Table 4, while the payoffs for the managers are presented in Table 5. When examining the managers' decisions in the second stage, it becomes clear that the subgame is influenced by the owners' choice of (P, P) or (R, R) in the first stage, each manager has a dominant strategy of choosing H. In the subgame that follows the owners' choice of (P, R), the Nash equilibrium is (L, H). In the subgame that follows the owners' choice of (R, P), the Nash equilibrium is (H, L). This means that in these subgames, the manager of the firm that selected the incentive scheme R will choose high output (H), while the manager of the firm that chose P will choose

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<sup>11</sup> Normann and Wallace (2012) show that a finite repeated game is not affected by a termination rule.

<sup>12</sup> See Appendix A.2, which includes additional assumptions to describe the owners' and managers' payoff tables for the experiment.

<sup>13</sup> See Benoit and Krishna (1987).

low output (L).<sup>14</sup>

In the first stage, each owner has a higher payoff with R than with P, regardless of the other firm's incentive scheme. This is because 1,111 is less than 1,222 and 702 is less than 800, as shown in Table 4. Therefore, the subgame perfect equilibrium in the single-period stage game is for both owners to choose R and for the managers to choose H, unless their owner has chosen P and the other owner has chosen R. In this case, the manager with contract P will choose L and the manager with contract R will choose H.

The finitely repeated game has a unique subgame perfect equilibrium, where both owners play strategy R, and both managers play strategy H in each period. This results in a payoff of 800 to each owner and 108 to each manager in each period. Communication in the PC treatment is cheap talk and does not affect the set of equilibrium outcomes.

**Hypothesis 1.a.** *With communication, the cartel formation rate under profit maximization (PC) does not differ from that under delegation (DC)*

**Hypothesis 1.b.** *Without communication, the cartel formation rate under profit maximization (PN) does not differ from that under delegation (DN)*

The remaining two hypotheses focus on the impact of communication on cartel formation in both delegation and no delegation (profit maximization) contexts. Previous studies have demonstrated that communication can facilitate cooperation and reduce conflict among subjects, leading to an increase in the formation of cartels (Fonseca and Normann, 2012; Awaya and Krishna, 2016; Bigoni et al., 2019). However, these studies have not considered the impact of firm owners' delegation to managers. Therefore, this paper seeks to examine the impact of communication on cartel formation in both delegation and profit maximization settings, with the formation of "tacit cartels" in PN and DN treatments and "total cartels" in PC and DC treatments.<sup>15</sup> Based on previous research, it is hypothesized that communication may increase the formation of cartels in both delegation and profit maximization scenarios.

**Hypothesis 2.a.** *Under profit maximization, the cartel formation rate with communication (PC) is higher than that with no-communication (PN)*

**Hypothesis 2.b.** *Under delegation, the cartel formation rate with communication (DC) is higher than that with no-communication (DN)*

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<sup>14</sup> As discussed earlier, these Nash equilibria for the subgames capture the managers' decisions in a competitive setting. When owners select (P,R) or (R,P), the manager with R chooses L, as there is more incentive to deviate from a cartel, while the manager with P chooses H, as there is little incentive to deviate from a cartel.

<sup>15</sup> Allowing communication does not necessarily result in the formation of explicit cartels. During the pilot test of my study, a few cartels formed without communication despite communication being allowed. This suggests that when communication is permitted, the resulting cartels may include both explicit and implicit cartels, both of which can be referred to as total cartels.

## 5 Results

This section discusses the results from the experiment. Section 5.1 examines how market outcomes are determined in the four treatments. Section 5.2 compares cartel formation rates and investigates how cartels are formed in each treatment. Section 5.3 focuses on how cartels are formed in each round and investigates how cartels change after detection by an antitrust authority in the experiment.

### 5.1 Market outcome

This section discusses how the experimental results in terms of profit and output are determined in the four treatments. Table 6 shows the “market profit” and “market output” for each treatment, as depicted in Figure 1. The market profit for each treatment is calculated as the average profit of each group (consisting of two firms) over all sixteen rounds, and is represented as the total profit of all firms divided by 160 (16 rounds per group multiplied by 10 groups). The table indicates that the market profit under the DN treatment (1,855) is lower than that under the PN treatment (2,244), as supported by the Mann-Whitney U (MW) test result ( $p = .001$ ) for DN and PN. On the other hand, the market profit under the DC treatment (2,125) is lower than that under the PC treatment (2,326), however, this finding is not supported by the MW test result ( $p = .174$ ) for DC and PC.

	PN	PC	DN	DC
<b>Market profit</b>	2,244	2,326	1,855	2,125
<b>Market output</b>	65.8	60.9	73.7	66.1

\* Market profit (output) = all firms’ profit (output) divided by 160 (= 16 rounds  $\times$  10 groups)

Table 6: Market outcomes across treatments

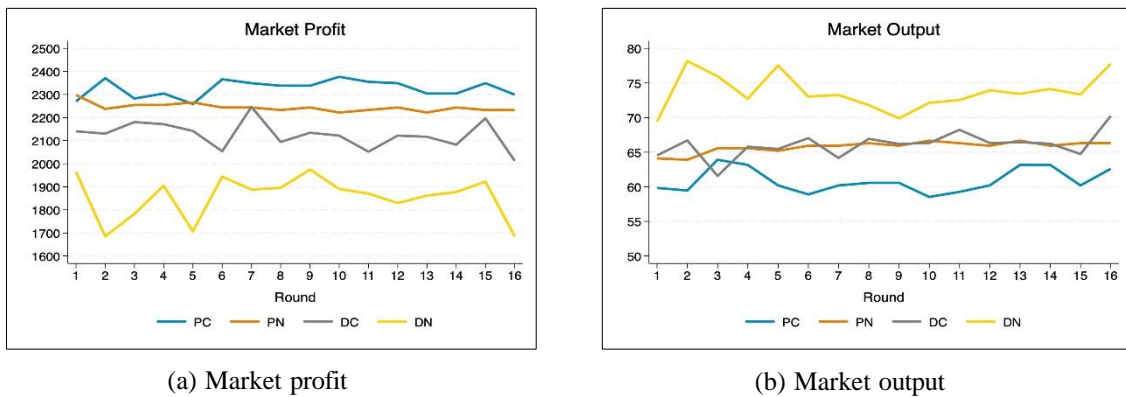


Figure 1: Market outcomes over the sixteen rounds for all treatments

The results of the experiment show that market output in DN treatment (73.7) is higher than that in PN treatment (65.8), which is supported by the MW test with  $p = .001$ . The market output in DC treatment (66.1) is also higher than that in PC treatment (60.9), but this finding is not supported by the MW test with  $p = .174$ . The results of market output are consistent with the findings of market profit, where the DN treatment shows lower profit but higher output than the PN treatment. On the other hand, the DC treatment does not differ statistically significantly from the PC treatment in either market output or profit.

## 5.2 Cartel formation under antitrust regulation and delegation

This section compares the rates of cartel formation under the PN and DN treatments, as well as under the PC and DC treatments. The rates of cartel formation are presented in Table 7. There is no significant difference ( $p = .849$ ) in the cartel formation rates between PC (51.3%) and DC (48.1%), supporting Hypothesis 1.a. However, the cartel formation rate under PN (0.6%) is lower than that under DN (8.8%), with a MW test result of  $p = .045$ , which does not support Hypothesis 1.b. This implies that when communication is allowed, delegation does not increase the number of cartels, but when communication is not allowed, delegation may increase cartels. This result also suggests that previous research that used the profit maximization assumption and estimated results such as the rates of cartel formation and detection by antitrust authorities remains relevant, even when it describes a market that does not consider delegation.

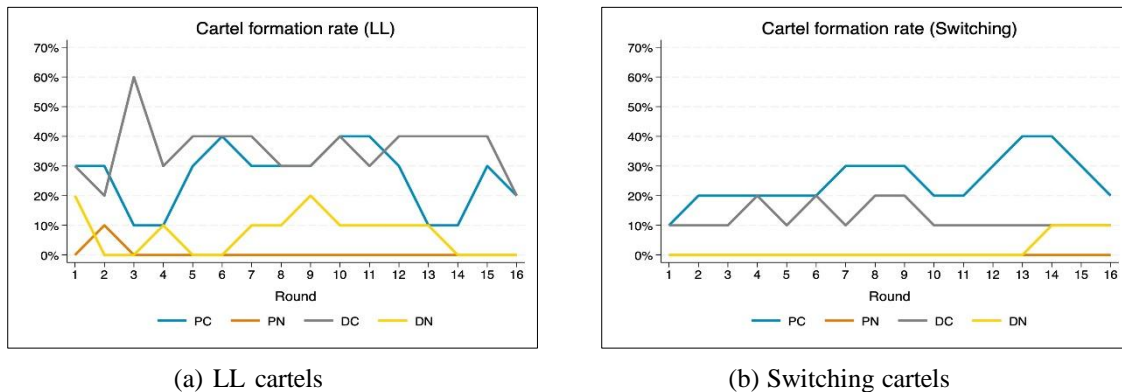
This experiment investigates how firms form cartels under antitrust policies. Two distinct forms of cartels are identified: “LL” cartels and “switching” cartels. LL cartels are established when both managers select “L,” while switching cartels occur when the managers alternate choosing “L” and “H”

	PN	PC	DN	DC				
				PP/RR	PR/RP		PP/RR	PR/RP
Cartels	<b>1</b>	<b>82</b>	<b>14</b>	6	8	<b>77</b>	39	38
(%, rate)	<b>(0.6%)</b>	<b>(51.3%)</b>	<b>(8.8%)</b>	(6.1%)	(12.9%)	<b>(48.1%)</b>	(39.4%)	(62.3%)
LL	1	42	11	3/-	3/5	57	18/14	11/14
Switching	-	40	3	3/-	-/-	20	2/5	11/2
Sample size	160	160	160	98	62	160	99	61

\* Cartel formation rate = cartels formed divided by 160 (16 rounds  $\times$  10 groups)

\*\* PP(RR) refers to cases in which (P,P) or (R,R) is chosen in stage 1, defined as symmetric cases. PR and RP are asymmetric cases.

Table 7: Cartel formation rates by treatment



(a) LL cartels  
 (b) Switching cartels

\* LL cartels describe cases in which both managers choose L.  
 \*\* Switching cartels alternate their choices every round, for example, (L,H), (H,L), (L,H) and so on.

Figure 2: LL and switching cartel formation rates over the sixteen rounds for all treatments

from round to round.<sup>16</sup> The presence of switching cartels suggests that cartel members are attempting to avoid punishment from antitrust authorities and that they may form other types of cartels in the absence of antitrust regulations. Table 7 and Figure 2 present the two forms of cartels identified in the experiment. In the PC treatment, LL cartels constitute half of all observed cartels (42 out of 82), while in the DN and DC treatments, they make up over two-thirds of the cartels (11 out of 14 and 57 out of 77, respectively). No statistically significant differences in the formation rates of LL cartels are observed between the PC and DC treatment ( $p = .643$ ), but delegation is found to result in a higher rate of LL cartel formation in the absence of communication ( $p = .045$ ). This suggests that under both delegation and profit maximization, cartels can be formed through mutual agreement between two firms to either choose (L, L) or alternate choosing L and H to evade cartel fines. However, delegation was found to result in a higher rate of LL cartel formation compared to profit maximization.

In addition, this study examines the differences in cartel formation rates when owners choose the same contract versus different contracts in the DN and DC treatments. Symmetric cases where owners choose either (P, P) or (R, R) are denoted by “PP/RR,” while asymmetric cases where owners choose either (P, R) or (R, P) are denoted by “PR/RP.” The results indicate that in the DN treatment, the cartel formation rate is higher in the PR/RP cases (12.9%) than in the PP/RR cases (6.1%). Similarly, in the DC treatment, the cartel formation rate is higher in the PR/RP cases (62.3%) than in the PP/RR cases (39.4%). These comparisons suggest that under the delegation scenario, managers are more

<sup>16</sup> In the experiment, as discussed in OECD (2007), Jaspers (2017), Aoyagi (2003), and Rachmilevitch (2013), cartels characterized by a predetermined pattern of pricing, specifically bid rotation in auctions, were clearly identified through the participants’ chat content. In the experiment, the subjects, who were acting as managers, engaged in discussions about how to collude with each other. For instance, they said, “OK, how about in this round I choose ‘H’ and you choose ‘L’? Then we can switch in the next round?” These interactions in treatments where communication is typically present, collusions in the form of discussing L-H-L or H-L-H with an opposing player to consistently gain excess profits through at least 3 rounds or more were observed. Consequently, instances where such patterns persisted for three or more rounds were considered switching cartels. See Appendix B.

likely to form cartels when the incentive schemes offered by their owners differ. This is supported by the MW test results ( $p=.041$  in DN and  $p=.005$  in DC).

The way the asymmetry is incorporated in the experiment design differs from previous studies, namely in [Ivaldi et al. \(2003\)](#), [Mason et al. \(1992\)](#), [Mason and Phillips \(1997\)](#), and [Fonseca et al. \(2005\)](#). Previous research established a “fixed” asymmetric duopoly situation where one firm is always more cost-efficient than the other. In such a scenario, if the two firms collude, one firm always has a stronger incentive to deviate from the collusion, leading to instability in the cartel. However, this study allows owners to change their selections, resulting in shifting asymmetry between the managers of different firms every round. This introduces uncertainty for managers choosing between L and H in the current round, as they do not know what their owners will choose in the next round. As a result, the comparison of cartel formation rates between symmetric and asymmetric environments in this experiment provides an insight into cartel behavior under conditions of changing asymmetry.<sup>17</sup>

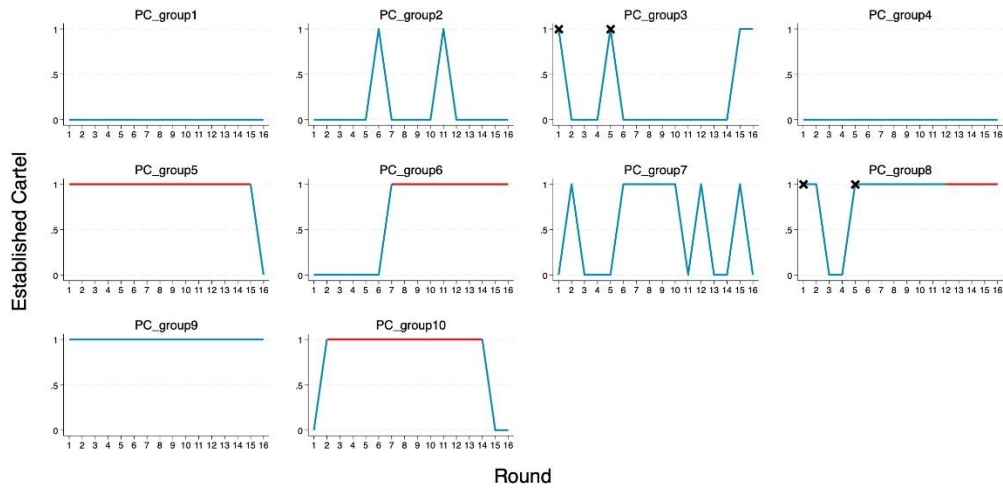
### 5.3 Cartel formation in successive rounds and changes post-detection

This section illustrates how each firm engages in collusion for each treatment and round, as well as the impact of an antitrust authority’s monitoring. Each group represents a market consisting of two firms, and data related to cartel formation among 10 groups over 16 rounds per treatment are presented in the figures below. The vertical axis of each panel represents cartel formation, with 1 indicating a cartel and 0 indicating no cartel, while the horizontal axis represents the rounds. Each treatment is indicated by a unique color, and periods marked by red lines indicate the formation of switching cartels, where collusion to evade the experiment’s antitrust policy was revealed in chats.

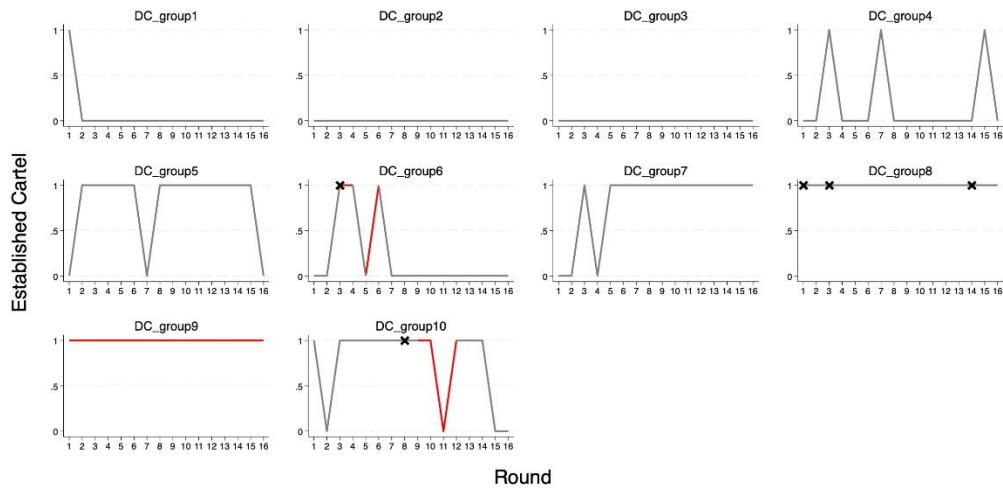
Figure 3 shows the cartels formed when communication is allowed. The PC and DC treatments have 10 groups indicating markets, and eight markets in each treatment formed cartels at least once. Analyzing the markets that formed cartels, two groups emerge: those who chose LL cartels and ignored fines (markets 7 and 9 in PC, and markets 5,7, and 8 in DC) and those who formed switching cartels to avoid fines (markets 5,6 and 10 in PC, and market 9 in DC). Because managers’ payoffs are influenced by owners’ choices, the payoffs for managers in the DC treatment are more intricate than those in the PC treatment. There is an observed tendency for switching cartels to more frequently opt for LL cartels to uphold mutual trust, considering the influence on each firm manager’s payoff with shifts in owners’ decisions. Consequently, the DC treatment exhibits a higher proportion of LL cartels than the PC treatment, as shown in Table 7 and further detailed in Appendix B, which contains chat logs categorized by cartel type.

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<sup>17</sup> Table 5 indicates the differences in incentives for the two managers to defect from collusion when (P, R) or (R, P) is selected. For example, if (P, R) is chosen, the difference in the payoffs for the Firm 1’s manager between colluding and defecting is  $13.9 = (148 - (.85 \times 138 + .15 \times 112))$ . The difference in payoffs for the manager of Firm 2 is  $24.5 = (145 - (.85 \times 124 + .15 \times 101))$ . This illustrates that the Firm 2’s manager has a stronger incentive (24.5) to deviate from collusion than the manager of Firm 1 (13.9). If (R, P) is chosen, the manager of Firm 1 is more likely to defect from collusion than the manager of Firm 2. The managers’ incentives to defect from collusion will change as the owners switch between P and R each round.



(a) PC



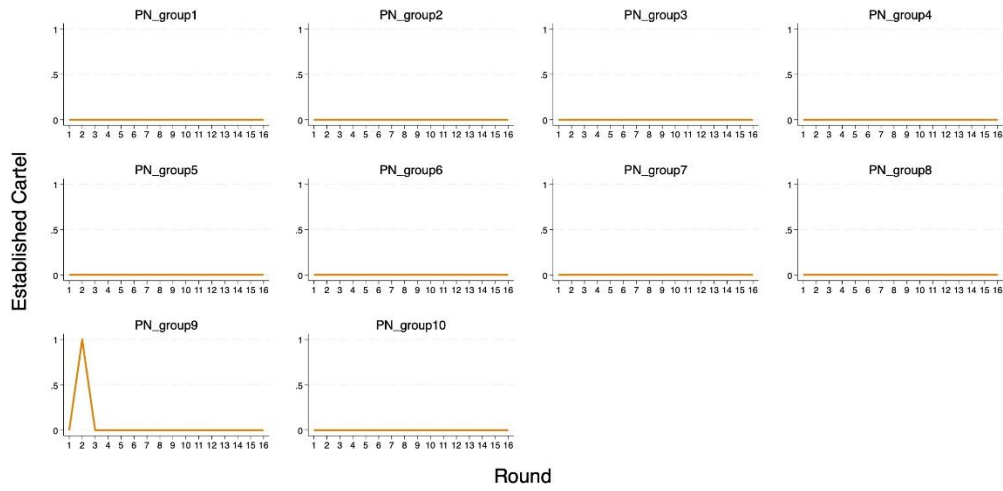
(b) DC

\* Black crosses indicate situations where a cartel has been detected with a 15% chance. A unique colored line shows LL cartels and each red-colored line represents switching cartels.

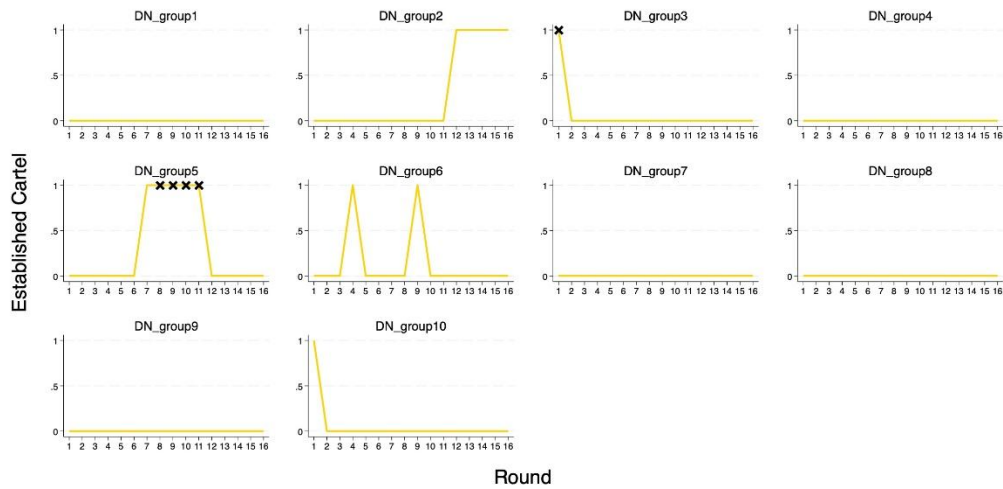
Figure 3: Cartel formation rates by group in PC and DC treatment

Figure 4 shows scenarios where communication is not permitted. The PN and DN treatments have one and five markets that form cartels, respectively. When communication is not permitted, it is not possible to exhibit clear signals of collusion. Therefore, in the PN treatment, cartels are almost non-existent. In contrast, in the DN treatment, cartels of a repetitive nature, involving three or more iterations after trial and error, are formed (e.g., markets 2 and 5 in DN). However, it is challenging to form switching cartels that can evade antitrust regulations, as observed in the PC and DC treatments.

Black crosses represent events where there is a 15% chance of a cartel being punished. In the DC treatment, five cartel punishments occur; four cartels are punished in PC and five in DN. Some groups



(a) PN



(b) DN

\* Each black cross indicates a situation where a cartel has been detected with a 15% chance.

Figure 4: Cartel formation rates by group in PN and DN treatment

initially chose LL cartels, but upon detection and imposition of fines for collusion, altered their cartel formation strategy to switching cartels (markets 6 and 10 in DC). Additionally, to investigate the break-up of cartels in the following detection, I examined the mean difference. Table 8 indicates whether a cartel formed in the previous round continues in the subsequent round after a punishment event. It is observed that cartels do not decrease statistically significantly due to punishment events. In most cases, cartels persist even after fines are imposed, indicating no significant difference in the sustainability of cartels ( $p = .242$ ). Particularly in the DC treatment, markets 6 and 10 actively continue their cartels by changing their collusion methods to a switching cartel after punishment, facilitated by effective communication.

	<b>Total</b>	<b>PN</b>	<b>PC</b>	<b>DN</b>	<b>DC</b>
$E(y_{t+1} D_t = 0, y_t = 1)$	<b>0.843</b> (0.132)	0 (0.250)	<b>0.890</b> (0.098)	<b>0.7</b> (0.210)	<b>0.826</b> (0.144)
$y_{t+1} = 1$	129	-	65	7	57
$y_{t+1} = 0$	24	1	8	3	12
$E(y_{t+1} D_t = 1, y_t = 1)$	<b>0.714</b>	-	<b>0.5</b> (0.250)	<b>0.6</b> (0.240)	<b>1</b> (0.000)
$y_{t+1} = 1$	10	-	2	3	5
$y_{t+1} = 0$	4	-	2	2	0

\*  $y_t = 1$  signifies the formation of a cartel in round  $t$ , and  $D_t = 1$  indicates that the formed cartel is detected and fined in round  $t$ .  $E(y_{t+1}|D_t = 1, y_t = 1)$  represents the expected value of forming a cartel in round  $t + 1$  when a cartel is formed but fined in round  $t$ .

Table : The impact of antitrust authority

## 6 Conclusion

The current study used a laboratory experiment setting to compare cartel formation under delegation and profit maximization and to examine the effects of communication on cartel formation in both settings. Based on this two-by-two design, four hypotheses were formulated: (1) when communication is allowed, the cartel formation rate under delegation does not differ from that under profit maximization; (2) when communication is not allowed, the cartel formation rate under delegation does not differ from that under profit maximization; (3) under delegation, communication generates more cartels than no communication; and (4) under profit maximization, communication generates more cartels than no communication. The first, third and fourth hypotheses were supported. However, regarding the second, it turns out that in the absence of communication, delegation results in a higher number of implicit cartels than no delegation.

The primary finding of this research sheds light on the strategic formation of cartels to circumvent antitrust laws. The experiment incorporates fines for cartel formation and a 15% chance of detection by antitrust authorities. In the experiment, some cartels attempt to avoid penalties by alternating between low and high output, rather than jointly opting for low output in collusion. This evasion strategy, switching cartels, represents an effort by cartels to elude regulation by antitrust authorities, similar to bid rigging in auction markets, a strategy that has been widely discussed in the prior literature. This study illuminates a strategy that cartels can employ to evade antitrust regulation, suggesting policymaking and enforcement efforts must take such tactics into account.

Another important conclusion is that delegation may not alter the cartel formation rate, but it may influence the methods of cartel formation. The overall levels of cartel formation under delegation and profit maximization did not differ; however, under delegation, LL cartels were formed more than under profit maximization, and there were fewer switching cartels. In situations where the manager's incentive scheme can vary based on the owner's choice, determining collusion becomes challenging because managers, deciding to collude, alternate between collusive and competitive outputs, making it

difficult to achieve the mutually consistent payoffs achieved by switching cartels under profit maximization. In other words, in situations where payoffs were variable due to delegation, managers opted for LL cartels, as it was easier to build trust with their counterparts than had they tried to achieve mutually consistent payoffs as in a switching cartel under profit maximization.

Furthermore, this study highlights how asymmetry in market conditions affects cartel formation experimentally. Previous research has studied the formation of cartels in asymmetric duopoly situations, where firms face a “fixed” asymmetry in every period. In such situations, one firm often has a greater incentive to deviate from the cartel, making it easier for the cartel to break down. However, in this study, owners have the ability to change market conditions by selecting managers’ incentive scheme in each period. The unpredictability of market conditions makes it difficult for managers to determine whether the market will be symmetric or asymmetric in the next period. Consequently, this uncertainty about owners’ selection in the future leads to an increase in cartel formation. The experiment’s results show that managers form more cartels in asymmetric market situations than symmetric ones, aligning with the empirical findings of [Byrne and De Roos \(2019\)](#).

Lastly, this study shows that under antitrust policies, firms alter their methods of forming cartels, but cartels do not necessarily decrease. In treatments where communication is not permitted, punishment to cartels does not change the method for cartel formation. However, in treatments that allow communication, some groups shift to switching cartels, continuing their collusion. Even after collusion is penalized, most groups in the experiment persist in collusion, indicating that cartel punishment may not decrease the overall formation of cartels.

In conclusion, this study offers insights into antitrust policies and collusion. Antitrust authorities must not only examine cartel overcharges, the pivotal difference between collusive and competitive prices, but also investigate how collusive prices and production quantities evolve over the long term. This is particularly important in cases where collusion may masquerade as competition, as seen in switching cartels. Moreover, it is essential to consider the potential for cartels to adopt new forms after encountering antitrust penalties, deviating from conventional patterns.

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## Appendix

### A Determination of the payoffs used in the experiment

This section details the calculation of payoffs for owners and managers in the experimental delegation game. These payoffs derive from a two-stage delegation game that incorporates various scenarios. Depending on whether each manager's objective function is profit alone or weighted profit and revenue, the weighted values assigned to profit and revenue, and the parameters of the demand function and marginal cost, numerous scenarios are possible. As a result, the payoffs can vary widely, so they must be simplified for the experiment. Therefore, the following four points guide the calculation of the payoffs that practically implement delegation, competition, and collusion in a laboratory setting: (1) only the collusion of managers, who directly operate the company, is considered; (2) the parameter affecting the weighted values is set to align with the results of previous empirical research; (3) the payoffs for owners and managers are determined independently based on the incentive scheme chosen by the delegating owners and the production decisions of the managers, rather than being distributed from owners' payoffs to managers; (4) the issue arising from revenue being numerically greater than profit is addressed through a negative fixed payment.

#### A.1 Owners' payoff setting

The game presented in this paper is based on the two-stage duopoly game described in the FJSV papers. The game features two firms in a market, each consisting of one owner and one manager. The inverse demand function is  $p(q_1, q_2) = a - q_1 - q_2$ , and the marginal cost is  $c$ . The game is divided into two stages.

In stage 1, each owner selects a contract to incentivize their manager, choosing between **P** and **R**. In stage 2, each manager selects an output level to maximize their payoffs. If **P** is chosen in stage 1, the payoff for firm  $i$ 's manager is determined by  $\pi_i = (a - q_1 - q_2 - c)q_i$ , for  $i = 1, 2$ . If **R** is chosen in stage 1, the payoff for firm  $i$ 's manager is given by  $\lambda_i \pi_i + (1 - \lambda_i)R_i$ , where  $R_i = (a - q_1 - q_2)q_i$  for  $i = 1, 2$ . Here, the values of  $(\lambda_1, \lambda_2)$  depend on the owners' expectations about whether the managers will collude or compete.<sup>18</sup> If owners expect that the managers will collude with each other, then  $\lambda_1 > 1$  and  $\lambda_2 > 1$ . To ensure that  $0 \leq \lambda_i \leq 1$  for  $i = 1, 2$ , the experimental framework imposes the following restrictions on the owners' expectations:

**Assumption 1.** *Owners expect managers to compete with each other.*

To describe contract **R** in the experiment, this paper uses subgame perfect equilibrium weighted values  $(\lambda_1^*, \lambda_2^*)$  from the case where both owners select contract **R**. To calculate the values  $(\lambda_1^*, \lambda_2^*)$ ,

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<sup>18</sup> See [Lambertini and Trombetta \(2002\)](#).

we can use the objective function of each firm's manager, such as Equation (2) or (3) from the basic setup in Section 3.1. By backward induction, in stage 2,  $q_1$  and  $q_2$  are decided to maximize managers' incentives. Thus, the objective functions of the managers,  $U_1$  and  $U_2$ , should satisfy the first-order conditions with respect to  $q_1$  and  $q_2$ , which are denoted  $F_1$  and  $F_2$ , respectively:

$$\begin{aligned} F_1 &= \frac{\partial U_1}{\partial q_1} = a - 2q_1 - q_2 - c\lambda_1 = 0 \\ F_2 &= \frac{\partial U_2}{\partial q_2} = a - 2q_2 - q_1 - c\lambda_2 = 0 \end{aligned} \quad (4)$$

In stage 1, the owners of firms 1 and 2 individually determine  $\lambda_1$  and  $\lambda_2$  to maximize  $\pi_1$  and  $\pi_2$  simultaneously. First-order conditions can be obtained by using the differentiability of the best response curves  $q_1$  and  $q_2$  with respect to  $\lambda_1$  and  $\lambda_2$ , and are given as follows:

$$\begin{aligned} \frac{\partial \pi_1}{\partial \lambda_1} &= (a - c - 2q_1 - q_2) \frac{\partial q_1}{\partial \lambda_1} - q_1 \frac{\partial q_2}{\partial \lambda_1} = 0 \\ \frac{\partial \pi_2}{\partial \lambda_2} &= (a - c - 2q_2 - q_1) \frac{\partial q_2}{\partial \lambda_2} - q_2 \frac{\partial q_1}{\partial \lambda_2} = 0 \end{aligned} \quad (5)$$

A Jacobian matrix,  $\begin{bmatrix} \frac{\partial F_1}{\partial q_1} & \frac{\partial F_1}{\partial q_2} \\ \frac{\partial F_2}{\partial q_1} & \frac{\partial F_2}{\partial q_2} \end{bmatrix}$ , and its determinant can be derived by the implicit function theorem.

Define the determinant as  $J$ . By Cramer's rule,  $\frac{\partial q_1}{\partial \lambda_1}$  and  $\frac{\partial q_2}{\partial \lambda_1}$  are obtained:

$$\begin{aligned} \frac{\partial q_1}{\partial \lambda_1} &= -\frac{1}{J} \det \begin{bmatrix} \frac{\partial F_1}{\partial \lambda_1} & \frac{\partial F_1}{\partial q_2} \\ \frac{\partial F_2}{\partial \lambda_1} & \frac{\partial F_2}{\partial q_2} \end{bmatrix} = \frac{2}{J} \\ \frac{\partial q_2}{\partial \lambda_1} &= -\frac{1}{J} \det \begin{bmatrix} \frac{\partial F_1}{\partial q_1} & \frac{\partial F_1}{\partial \lambda_1} \\ \frac{\partial F_2}{\partial q_1} & \frac{\partial F_2}{\partial \lambda_1} \end{bmatrix} = -\frac{1}{J} \end{aligned} \quad (6)$$

Similarly, the equations for  $\frac{\partial q_2}{\partial \lambda_2}$  and  $\frac{\partial q_1}{\partial \lambda_2}$  can be derived. When equations (4), (5), and (6) are solved, the result is  $\lambda_1^* = \lambda_2^* = \frac{6c-a}{5c}$ . However, to ensure that  $\lambda_1$  and  $\lambda_2$  are non-negative, an additional assumption is adopted.

**Assumption 2.**  $a$  is satisfied with  $6c > a > c$  where  $c > 0$ .

In the experiment, therefore, contract P indicates that  $U_i^P = \pi_i$ , while contract R represents  $U_i^R = .5\pi_i + .5R_i$  for  $i = 1, 2$ . Using  $a = 140$  and  $c = 40$ ,  $\lambda_1^* = \lambda_2^* = .5$  is obtained. This value is consistent with the weighted values used to describe real-world compensation schemes in Bloomfield (2021).

## A.2 Managers' payoff setting

There are two additional assumptions related to managers' payoffs. The third assumption is that owners' profits are independent of managers' payoffs. Otherwise, the proportion of managers' payoffs to owners' profits would affect owners' decisions, and the model parameters would vary depending on how  $a$  and  $c$  are chosen. In the real world, a manager's payoff is typically much smaller than the profits of firms. To focus on the behavior of the firms described by the owners' and managers' selections, and to ensure that there is no change in these selections due to changes in the model parameters, this study makes the following assumption:

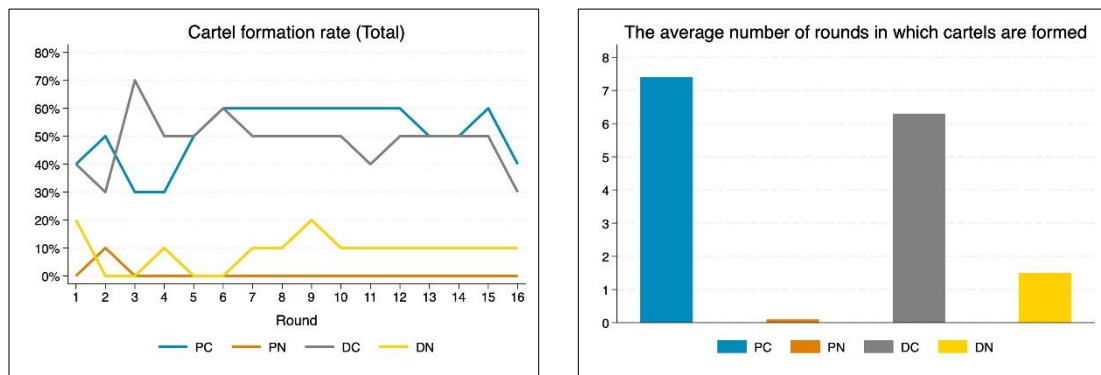
**Assumption 3.** *Each owner's payoff is independent of their manager's payoff.*

The fourth assumption pertains to the size of managers' payoffs. When an owner selects strategy R, their manager's payoff is determined by profit and revenue. Since revenue is greater than profit unless cost is zero, a manager's payoff under R is always greater than those under P. This can affect owners' decisions in stage 1. To account for this, a negative fixed payment is applied to managers' payoffs, as adopted by Huck et al. (2004). The negative fixed payment is equal to the gap in the average of managers' payoffs when an owner chooses R versus when both owners choose P. For example, if (R, R) is chosen, then  $U_1^R = .5\pi_1 + .5R_1 = (120 - q_1 - q_2)q_1$  and  $U_2^R = .5\pi_2 + .5R_2 = (120 - q_1 - q_2)q_2$ . Table 1 shows the possible outputs that managers of firms 1 and 2 can choose, which are (30, 30), (30, 45), (45, 30), and (40, 40). Half of the profit plus half of the revenue from these four outputs is calculated to be 1800, 1350, 2025, and 1600, respectively. The average of these numbers is 1694. Similarly, the average profit in the (P, P) case is 1173. Therefore, the gap between (R, R) and (P, P) is  $1694 - 1173 = 521$ , which is used as a fixed negative payment for the adjustment. The *adjusted calculations* are 1279, 829, 1504, and 1079, respectively. The negative payment does not affect the equilibria for the subgames. To ensure that an owner's profit is never smaller than a manager's payoff, the adjusted values are multiplied by 0.1 in the experiment. As a result, the adjusted payoffs for managers are 128, 83, 150, and 108, as displayed in Table 5.

**Assumption 4.** *Managers' expected payoffs for each case are constant regardless of owners' selections.*

## B Communication's effect and chats

This section examines the effect of communication on the formation of cartels. Figure A1 (a) shows the rates of cartel formation (LL cartels + switching cartels) over the course of sixteen rounds. The average formation rate of cartels in the PC treatment (51.9%) is higher than in the PN treatment (0.6%), and similarly, the average formation rate of cartels in the DC treatment (48.1%) is higher than in the DN treatment (10.0%). The MW test results indicate that communication treatments result in more cartel formation than no-communication treatments, with  $p = .001$  for PC and PN, and  $p = .062$  for DC and DN. This supports Hypotheses 2.a and 2.b.<sup>19</sup>



(a) Total cartels (LL + Switching cartels)

(b) The average number of cartels by treatment

\* Each treatment has ten groups that decide to form a cartel or not over sixteen rounds. Panel (a) illustrates the proportion of cartels formed in each round, while Panel (b) shows the average number of rounds it took for cartels to form in each group.

Figure A1: The effect of communication on cartel formation

Figure A1 shows the average number of rounds out of sixteen in which a cartel was formed. For example, in the PC treatment, cartels formed in 7.4 rounds on average, while in the PN treatment, cartels were almost nonexistent. Similarly, in the DC treatment group, cartels formed in 6.3 rounds on average, whereas in the DN treatment they formed in an average of 1.5 rounds out of sixteen. The results of the MW test for each comparison was statistically significant, with  $p = .001$  for PC versus PN and  $p = .062$  for DC versus DN. These findings support the conclusion that communication is crucial for consistent cartel formation, as it reduces the trial and error associated with cartel formation in the absence of communication when the opponent's strategy can only be observed.

<sup>19</sup> This experiment compares the impact of communication on cartel formation under delegation and profit maximization. Delegation treatments also involve an asymmetric duopoly setting, as discussed in Section 5.2. The experiment observes two types of cartels: LL cartels and switching cartels. The results show that communication increases the formation of both types of cartels. There are more LL cartels in the PC treatment (26.3%) than in PN treatment (0.6%). The formation of LL cartels is also higher in the DC treatment (35.6%) than in the DN treatment (6.9%). Furthermore, communication is found to result in more switching cartels, as seen in the comparison between PC and PN (25.6% vs. 0%) and DC and DN (12.5% vs. 1.9%).

In addition, employing the method of [Kimbrough et al. \(2008\)](#) and [Fonseca and Normann \(2012\)](#) to analyze chat communications, examples are provided from managers' chat as they made decisions regarding collusion in the PC and DC treatments. The chat communications reveal how colluding firms navigate antitrust policies, evade detection, and build trust with one another. To prevent the influence of the abbreviations L and H, representing low and high, in the experimental results, A and B were used in their place in the instructions offered to subjects. In other words, LL cartels are described as managers choosing A and A, while switching cartels involve periodically alternating between A and B. The chats are broadly categorized into five types as follows:

(1) Choosing LL cartels while ignoring regulations - **Market 5 in DC**

Firm 1's manager: We should go A

Firm 2's manager: But the fine?

Firm 1's manager: Go A

Firm 2's manager: Bet

Firm 1's manager: The fine is not important

(... a few rounds later)

Firm 2's manager: Go B Firm 1's manager: Why?

Firm 2's manager: I don't know there is gonna be a fine at some point. Why not?

Firm 1's manager: it's only 23 points.

This underscores that cartel firms might ignore antitrust regulations, even in markets with existing antitrust policies, as long as the expected fines imposed on cartels, considering the detection rate, are low.

(2) Persisting with switching cartels to evade regulations - **Market 10 in PC**

Firm 1's manager: Do we want to try doing A and B? I do not want to risk getting fined if we both choose A.

Firm 2's manager: Ok. If you do A, then I will do B.

Firm 1's manager: That sounds good to me.

Firm 2's manager: Perfect!

Firm 1's manager: and then at 16 we should end at the same amount right because we started with 1111

Firm 1's manager: I can't figure it out that far in advance haha. Let's just keep switching off and then at 14 we will evaluate. we are epic-economists.

Firm 2's manager: OK, so I am B and you choose A for this one.

This specifically illustrates collusion that evades regulatory measures. It indicates the potential existence of cartels in the market that avoid antitrust regulations, even with low detection rates and fines.

(3) Initially attempting LL cartels but looking for an alternative way to form a cartel after fines are imposed - **Market 8 in DC**

Firm 1's manager: It seems like we should go A.

Firm 2's manager: If one of us goes B, we'll just get locked into both going B each round.

... (after the punishment at round 8)

Firm 1's manager: Okay, so we got fined last time but chances are we won't this time.

Firm 2's manager: It seems like a 15% chance of around 20% fine.

Firm 1's manager: We can try alternating an AB mix, then swap next time.

Firm 2's manager: That makes a lot of sense now if we swap AB each round.

Firm 1's manager: Well, actually it's probably less useful. B gets 16 more but A gets 32 less

While the above case (2) indicates actions taken in anticipation to evade regulations, (3) suggests the emergence of cartels that evade regulations after facing punishment from regulatory authorities.

(4) Dissolution of collusion after fines are imposed - **Market 3 in PC**

Firm 1's manager: Are you interested in joining a market agreement with me? This means we both select A!

Firm 2's manager: If one of us goes B, we'll just get locked into both going B each round.

... (after the punishment at round 3)

Firm 1's manager: I have not been so lucky thus far.

Firm 2's manager: same.

Firm 1's manager: I would like to try and select A for the extra earnings.

Firm 2's manager: I am skeptical. I feel safer selecting B.

This illustrates a situation where collusion does not recur due to firms' fears of regulation following actual fines, generally reflecting the anticipated collapse effect of cartels by antitrust policies.

(5) Failure to build trust even when communication is permitted - **Market 4 in PC**

Firm 1's manager: Click A all the way 1250 is good.

Firm 2's manager: You got it.

Firm 1's manager: The fine is not important.

Firm 2's manager: 1250 is consistent just choose A everytime!

... (after both chose B)

Firm 1's manager: What happened? You chose B. Choose a every time.

Firm 2's manager: A?

... (after both chose B again)

Firm 1's manager: Bro, stop playing dumb!

Firm 2's manager: I'm gonna do A.

... (after both chose B one more round)

Firm 1's manager: You're a liar! This is your fault. I can't trust you buddy.

This illustrates a common example of the failure of cartel formation often discussed in the context

of the Prisoner's Dilemma, where competition arises due to concerns about the counterpart's deviation.

### C Mann-Whitney U (MW) test results by treatment

In this section, the table cells present the Mann-Whitney U test (MW test) results for the treatments outlined in the rows and columns. The tables below show the results of the MW test for each treatment, with one observation per group over 16 rounds, the results of which use 10 observations per treatment. Each treatment corresponds to the establishment of cartels, determined by managers' choices across 10 groups over 16 rounds. As previously explained, cartels are classified into LL cartels and switching cartels. Panels in Tables A1 and A2 represent the comparison of the MW test results from profit, output, and cartel formation rates among the different treatments.

	PN	DC	DN		PN	DC	DN
PC	0.149	0.174	0.001	PC	0.003	0.174	0.000
PN	-	0.129	0.001	PN	-	0.762	0.002
DC		-	0.013	DC		-	0.034

(a) Market profit

(b) Market output

Table A1: p-values from MW tests of treatment differences in market output and profit

	PN	DC	DN		PN	DC	DN		PN	DC	DN
PC	0.001	0.849	0.023	PC	0.013	0.643	0.204	PC	0.091	0.351	0.192
PN	-	0.002	0.045	PN	-	0.005	0.045	PN	-	0.466	0.466
DC		-	0.062	DC		-	0.147	DC		-	0.871

(a) Total cartels (LL+Switching)

(b) LL cartels

(c) Switching cartels

Table A2: p-values from MW tests of treatment differences in cartel formation rate

## D Quiz and Instructions (DC treatment)

### Testing your knowledge of reading the payoff table

Thank you for joining this experiment! Before going to today's main experiment, we want to familiarize you with the payoff table, which will be helpful for making good decisions during this experiment. To start, please carefully read the following explanation. Then on the next page, you will see some quizzes to test your knowledge of the concept, and the results of the test will help **your payoff** from today's experiment. So, make sure to do your best to understand the concept.

The following payoff table illustrates the payoffs determined by the choices of two players. You are the row player, and your opponent is the column player. The payoffs in each cell are listed in the order (your payoff, opponent's payoff), with the number in blue representing your payoff in each scenario. The following four cases are possible:

- If you select A and the other player selects A, you receive 128.
- If you select A and the other player selects B, you receive 83.
- If you select B and the other player selects A, you receive 150.
- If you select B and the other player selects B, you receive 108.

		The opponent	
		A	B
You	A	128, 128	83, 150
	B	150, 83	108, 108

Let's consider the following case. The only difference from the above table is that if you select A and the other player selects A, the payoff is determined probabilistically. That is,

- If you select A and the other player selects A, you have an 85% chance of receiving 128 and a 15% chance of receiving 102.

		The opponent	
		A	B
You	A	128, 128 with 85% or 102, 102 with 15%	83, 150
	B	150, 83	108, 108

Let's consider a different type of payoff table. The following payoff table shows the payoffs when you and your opponent choose either P or R, and then two other players choose either A or B. In other words, your opponent, who makes a decision at the same time as you, chooses between P and R, resulting in four possible combinations: P and P, P and R, R and P, and R and R. Then, depending on how the other two players choose A or B, your payoff is determined. The payoffs for each scenario are as follows:

- If you select P and the other selects P, then your earnings will be 1250 or 925 or 1406 or 1111.
- If you select P and the other selects R, then your earnings will be 1125 or 702 or 1225 or 630.
- If you select R and the other selects P, then your earnings will be 1350 or 1050 or 1222 or 846.
- If you select R and the other selects R, then your earnings will be 1200 or 750 or 1125 or 800.

		The opponent					
		P			R		
You	P		A	B		A	B
		A	1250, 1250	925, 1406	A	1125, 1350	702, 1222
	B	1406, 925	1111, 1111	B	1225, 1050	630, 846	
	R		A	B		A	B
		A	1350, 1125	1050, 1225	A	1200, 1200	750, 1125
	B	1222, 702	846, 630	B	1125, 750	800, 800	

You don't have to memorize these payoff tables. It is sufficient to understand how the payoff is determined based on your choice and your opponent's choice. If you still don't understand how to read the payoff table, please carefully re-read this page. Your payoff from this experiment will be influenced by how well you understand the payoff table. If you feel you do understand the payoff table, please click the **next button** to proceed.

(Next page)

Here are **three quizzes**. If you solve all the quizzes correctly, then you can get 1 dollar as a bonus. Otherwise, you cannot get any bonus. Please solve the quizzes below.

**Quiz 1)** There is a payoff table for you and your opponent. When you select B and the other selects A, which is the payoff you will get?

		The opponent	
		A	B
You	A	128, 128	83, 150
	B	150, 83	108, 108

- (a) 128
- (b) 83
- (c) 150
- (d) 108

**Quiz 2)** There is a payoff table for you and your opponent. When you select A and the other selects A, which is the correct description of you and your opponent's payoffs?

		The opponent	
		A	B
You	A	128, 128 with 85% or 102, 102 with 15%	83, 150
	B	150, 83	108, 108

- (a) You and your opponent will get 128 with certainty
- (b) You and your opponent will get 102 with certainty
- (c) You and the other have an 85% chance of getting 128 and a 15% chance of getting 102
- (d) You will get 128 while your opponent gets 102 with certainty

**Quiz 3)** There is a payoff table for you and your opponent who selects P or R. What are the possible scenarios for your payoff if you select P and your opponent selects R?

		The opponent					
		P			R		
You	P	A	B	A	B		
		A	1250, 1250	925, 1406	1125, 1350	702, 1222	
	B	1406, 925	1111, 1111	1225, 1050	630, 846		
	R	A	B	A	B		
		1350, 1125	1050, 1225	1200, 1200	750, 1125		
	1222, 702	846, 630	1125, 750	800, 800			

- (a) Your earnings will be one of the following: 1250 or 925 or 1406 or 1111.
- (b) Your earnings will be one of the following: 1125 or 702 or 1225 or 630.
- (c) Your earnings will be one of the following: 1350 or 1050 or 1222 or 846.
- (d) Your earnings will be one of the following: 1200 or 750 or 1125 or 800.

Please click the next button if you completed the three quizzes.

Through the three quizzes, you can learn how to read payoff tables for the experiment. The answer key for the quizzes is as follows:

**Quiz 1)** When you select B and the other selects A, your payoff will be 150. So, (c) is correct.

		The opponent	
		A	B
You	A	128, 128	83, 150
	B	150, 83	108, 108

**Quiz 2)** When you select A and the other selects A, you and the other have an 85% chance of getting 128 and a 15% chance of getting 102. So, (c) is correct.

		The opponent	
		A	B
You	A	128, 128 with 85% or 102, 102 with 15%	83, 150
	B	150, 83	108, 108

**Quiz 3)** When you select P and your opponent selects R, your earnings will be 1125 or 702 or 1225 or 630. So, (b) is correct.

		The opponent					
		P			R		
You	P	A	B	A	B	A	B
		A	1250, 1250	925, 1406	1125, 1350	702, 1222	
	B	1406, 925	1111, 1111	1225, 1050	630, 846		
	R	A	B	A	B		
A	1350, 1125	1050, 1225	1200, 1200	750, 1125			
B	1222, 702	846, 630	1125, 750	800, 800			

Click "Next" to read the instructions for today's main experiment!

## General Instructions

This is an experiment in economic decision-making in a market. In the experiment, you will be grouped with three other participants. Each group corresponds to a market consisting of two firms, 1 and 2. Each firm has one owner and one manager. You will have a role of either an owner or a manager in a firm. Your role is kept until the end of this experiment. The experiment consists of 16 rounds in total.

Your earnings today will be determined by your and others' choices. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of money. The currency used in the experiment is the 'Point.' If your role is an owner, 2,000 points are worth 1 dollar. If your role is a manager, 200 points are worth 1 dollar. You can see how much you earn at the end of each round, and then points will be converted to dollars after all 16 rounds are completed. In addition, you receive a show-up fee for completing the experiment.

Each round consists of two stages. The table below describes what each role should do in stages.

Stage	A participant's role	What does each participant select in each stage?	What do the decisions in each stage affect?
1	Owner	P or R	Earnings
2	Manager	A or B	Earnings and fine (Fine is imposed with a 15% chance if both managers choose A.)

In the first stage of each round, the participants who have a role of an owner select one between two strategies P and R. Your selection affects not only your earnings, but also your manager's earnings. At the end of the first stage in each round, there is an announcement to all participants about what strategies owners select in stage 1. Managers wait for owners' decisions during stage 1.

After the first stage is completed, the managers chat with each other for one minute. A payoff table depending on the owners' selection in stage 1 will be given to managers. During a chat, managers can talk with each other freely, but managers must not share personal information with others. No one who violates the rule will get any points.

In the second stage, managers choose (i) to join a market agreement (A) or (ii) not to join it (B). If both managers choose A, there is a 15% chance that owners and managers will pay a fine. Otherwise, no fine is imposed on anyone. Owners wait for the managers' chat and decisions during stage 2. After stage 2, earnings and fines for the participants are decided, and then a round is completed.

## Instructions for each stage

### Stage 1 – Owners’ decisions

In stage 1 of each round, the owners choose P or R. The table below indicates the owners’ earnings. P and R in gray cells mean owners’ possible choices. A and B in blue cells indicate managers’ possible choices. The owners’ choices in Stage 1 decide one among four cases, P and P, P and R, R and P, and R and R. Then, owners’ earnings will be one of the black numbers in boldface type in the table case by case.

Suppose that you are an owner. Then, earnings in the four possible cases are as follows;

- If you select P and the other owner selects P, then your earnings will be 1250 or 925 or 1406 or 1111.
- If you select P and the other owner selects R, then your earnings will be 1125 or 702 or 1225 or 630.
- If you select R and the other owner selects P, then your earnings will be 1350 or 1050 or 1222 or 846.
- If you select R and the other owner selects R, then your earnings will be 1200 or 750 or 1125 or 800.

Owners’ earnings		The opponent firm					
		P			R		
Your firm	P		A	B		A	B
		A	<b>1250</b> , 1250	925, <b>1406</b>	A	1125, 1350	702, 1222
		B	1406, 925	1111, 1111	B	1225, 1050	630, 846
	R		A	B		A	B
		A	1350, 1125	1050, 1225	A	1200, 1200	750, 1125
		B	1222, 702	846, 630	B	1125, 750	800, 800

### Stage 2 – Managers’ decisions

In stage 2, managers choose A or B, which decides earnings and fines for owners and managers. A different table for earnings is given to managers in stage 2, depending on owners’ selections in stage 1. The blue numbers in the tables below indicate managers’ earnings. Fines are already reflected on each table. Thus, all you have to do is to care about your earnings in the table given to you in each case.

Suppose that you are a manager. First, let’s look at the case that both owners choose P in stage 1.

- If you and the other manager select A, then you and the other manager get 125, respectively. With a 15% chance, you have to pay a fine, 23, and the other manager has to pay a fine, 23. With the other 85% chance, there are no fines.
- If you select A and the other manager selects B, then you get 93 and the other manager gets 141.
- If you select B and the other manager selects A, then you get 141 and the other manager gets 93.
- If you select B and the other manager selects B, then you get 111 and the other manager gets 111.

Managers' earnings	$U_2$ with P		
		A	B
$U_1$ with P	A	<b>125</b> , 125 with 85% or <b>102</b> , 102 with 15%	<b>93</b> , 141
	B	<b>141</b> , 93	<b>111</b> , 111

The second case is that the owner of your firm chooses P and the owner of the other firm chooses R in stage 1.

- If you and the other manager select A, then you get 138 and the other manager gets 124. With a 15% chance, you have to pay a fine, 26, and the other manager has to pay a fine, 23. With the other 85% chance, there are no fines.
- If you select A and the other manager selects B, then you get 95 and the other manager gets 145.
- If you select B and the other manager selects A, then you get 148 and the other manager gets 94.
- If you select B and the other manager selects B, then you get 88 and the other manager gets 107.

Managers' earnings	$U_2$ with R		
		A	B
$U_1$ with P	A	<b>138</b> , 124 with 85% or <b>112</b> , 101 with 15%	<b>95</b> , 145
	B	<b>148</b> , 94	<b>88</b> , 107

The third case is that the owner of your firm chooses R and the owner of the other firm chooses P in stage 1.

- If you and the other manager select A, then you get 124 and the other manager gets 138. With a 15% chance, you have to pay a fine 23, and the other manager has to pay a fine 26,. With the other 85% chance, there are no fines.
- If you select A and the other manager selects B, then you get 94 and the other manager gets 148.
- If you select B and the other manager selects A, then you get 145 and the other manager gets 95.
- If you select B and the other manager selects B, then you get 107 and the other manager gets 88.

Managers' earnings		$U_2$ with P	
		A	B
$U_1$ with R	A	124, 138 with 85% or 101, 112 with 15%	94, 148
	B	145, 95	107, 88

The fourth case is that your firm's owner chooses R and the other firm's owner chooses R in stage 1.

- If you and the other manager select A, then you and the other manager get 128 respectively. With a 15% chance, you have to pay a fine 26, and the other manager has to pay a fine 26, 2. With the other 85% chance, there are no fines.

- If you select A and the other manager selects B, then you get 83 and the other manager gets 150.
- If you select B and the other manager selects A, then you get 150 and the other manager gets 83.
- If you select B and the other manager selects B, then you get 108 and the other manager gets 108.

Managers' earnings		$U_2$ with R	
		A	B
$U_1$ with R	A	128, 128 with 85% or 102, 102 with 15%	83, 150
	B	150, 83	108, 108

In addition, fines are imposed on owners with a 15% chance if both managers choose A. The table below indicates each of the cases where both managers choose A, and fines are imposed on owners, depending on owners' selections. If you are an owner, the table will be given to you in your decision.

Owners' earnings		The opponent firm					
		P			R		
Your firm	P	A	B		A	B	
		A	1250, 1250 with 85% or 1025, 1025 with 15%	925, 1406	A	1125, 1350 with 85% or 912, 1095 with 15%	702, 1222
		B	1406, 925	1111, 1111	B	1225, 1050	630, 846
	R	A	B		A	B	
		A	1350, 1125 with 85% or 1095, 912 with 15%	1050, 1225	A	1200, 1200 with 85% or 960, 960 with 15%	750, 1125
		B	1222, 702	846, 630	B	1125, 750	800, 800

In brief, your total earnings depend on 1) whether owners select P or R, 2) whether managers select A or B. Please click the next button to go to stage 1 in round 1.